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DEPARTMENT OF THE ARMY
NEW ENGLAND DISTRICT
CORPS OF ENGINEERS
CONCORD, MASSACHUSETTS

INVESTIGATION OF LYMANSVILLE AND MANTON DAMS
WOONASQUATUCKET RIVER, RHODE ISLAND

MAY, 2005

LYMANSVILLE AND MANTON DAMS
WOONASQUATUCKET RIVER, RHODE ISLAND

1. PURPOSE AND SCOPE

At the request of the management team associated with the Centredale Superfund project an engineering team re-inspected Lymansville and Manton dams. The purpose of this inspection was to compare the current dam conditions with the conditions reported by a similar team that inspected these same dams for the State of Rhode Island in 1999. The 1999 inspection (report titled, Woonasquatucket River Dam Investigations, dated June 1999) resulted in recommendations for dam safety issues and this inspection was intended to determine if the past recommendations are still valid or if conditions have changed to such an extent that additional recommendations may be considered now.

2. INSPECTION TEAM

Mark Vance – Geotechnical Engineering
David Cole - Structural Engineering
Mark Geib - Hydrologic/Hydraulic Engineering

3. SUMMARY

Based on visual inspection conducted on May 17, 2005, these two dams are generally in the same condition as reported during the 1999 inspection. Dam conditions have not significantly changed from those observed in 1999 and the past recommendations are still considered valid. Some minor changes were observed (see below) that have resulted in a slight change in recommended remedial repairs. Based on visual inspections these two dams are in generally fair condition and do not show signs of immediate danger of dam failure. However there continues to be a lack of maintenance and minor repair is needed. Structural engineering recommendations from this inspection are included below however the entire structural engineering inspection reports (for both dams) are attached as Attachments 1 & 2.

No additional hydrologic analysis was conducted for this inspection because the analysis presented in the 1999 report is still considered applicable. As stated in that report neither of these spillways meet Corps of Engineers hydrologic criteria for spillway design (i.e. full or half PMF), however analysis shows that significant backwater conditions are present during frequent to moderate floods (i.e. 100 year). The head differential across these two dams is less during a 100 year flood than during normal conditions. It was therefore concluded that these dams are not likely to fail catastrophically during floods of this magnitude however overtopping of earth embankments could result in erosion,

embankment failure and loss of sediment from the pond. It was therefore recommended to ensure adequate performance that the embankments be cleared of vegetation, the embankment crest erosion repaired, and toe, slope and crest protection should be placed immediately. In addition to this recommendation a shallow toe drain system should be constructed along the entire downstream edge of the embankment for both dams. This is to control the observed seepage and any increase in future seepage rates.

4. LYMANSVILLE DAM.

Lymansville Dam has not significantly changed since the last inspection was performed in April 1999. However several seepage areas along the dam embankments downstream toe have developed that were not previously reported. On the eastern portion of the embankment two small seeps flowing about 2-3 gpm each are located near the downstream end the spillway training wall. The first is located about 8 feet off the dams toe and about 20 feet from the spillway wall. This seep was flowing clear but had significant accumulations of iron staining deposited on the ground surface indicating that it has been flowing for sometime. The second seep was located at the base of a tree growing adjacent to the end of the spillway wall and was flowing clear at the time of inspection. Along the western portion of the embankment a large seepage and wet area was present along the downstream toe of the dam. Beginning at a point about 50 feet from the spillway training wall and extending 50 feet to the west was an active seepage area that was flowing clear at the time of the inspection. The rate of seepage was difficult to determine but is estimated at about 10-20 gpm over the 50-foot reach. Significant amounts of iron staining was also present within this reach indicating that its has been flowing for sometime. Adjacent to the westerly end of this active seepage area was a wet area about 40 feet in length along the toe, with no signs of active seepage. These areas appear to have been wet for a long period of time based on the dense wetland vegetation development and organic soils present. A large wetland below the dam was reported in the previous inspection but no seepage was noted at that time.

The previous reported findings and recommendations from the Woonasquatucket River Dam Investigation Report, June 1999 are still valid today and should be implemented. These include rehabilitation of gate structure 2 to allow use of the gate during emergencies, inspections and construction activities. The gate closest to the spillway has a significant amount of leakage and should be repaired immediately. A sudden failure of this gate will result in draining the pond with the possible loss of some of the pond sediments. Also, seal gate structure 1 to prevent erosion of the embankment and clearing of vegetation from embankments and gate structures. In addition to the previous recommendations a shallow toe drain and graded filter system should be constructed along the entire downstream edge of the embankment to control the observed seepage and any future increase in the seepage rates.

5. MANTON DAM

Manton Dam has not significantly changed since the last inspection was performed in April 1999. However a small seepage area located at the base of the

embankment and right abutment has developed that was not previously reported. This area appears to be an old channel extending below the dam, seepage was clear and flowing at about 1-2 gpm with heavy iron staining deposits present. A second area of seepage was observed at the base of the right spillway retaining wall and from under a tree growing adjacent to the end of the wall, seepage was clear and flowing at about 1-2 gpm. No seepage was noted in the previous inspection report.

The previous reported findings and recommendations from the Woonasquatucket River Dam Investigation Report, June 1999 are still valid today and should be implemented. These include repair the east abutment, replacing missing concrete, replace unsound concrete and repair cracks. Replace gates and support structure, this will aid in future inspections, emergencies and construction activities. In addition to the previous recommendations a shallow toe drain and graded filter system should be constructed along the entire downstream edge of the embankment to control the observed seepage and any future increase in the seepage rates.

ATTACHMENT 1

STRUCTURAL INSPECTION

LYMANSVILLE DAM

LYMANSVILLE DAM
WOONASQUATUCKET RIVER
NORTH PROVIDENCE, RHODE ISLAND

1. FIELD INSPECTION

David Cole from the Design Branch, Engineering/Planning Division of New England District of the Army Corps of Engineers, conducted the structural portion of the inspection of Manton Dam at North Providence, Rhode Island on 17 May 2005. Major features inspected are

- Spillway
- Gate Structures 1 2 & 3
- East Abutment
- West Abutment
- Apron

Elevations and dimensions used in this report are taken from drawing provided by the State of Rhode Island. The drawing title is "LYMANSVILLE", Plan No. 134. The drawing is dated 11-18-40.

a. Spillway

The spillway appears to be in overall good condition. There is minor to moderate surface abrasion and deterioration at the crest of the spillway. The spillway is 3.5 feet wide at the top and 8.5 feet wide at the bottom. The downstream face of the spillway is 8.4 feet tall. The distance between the east and west abutments is 105.0 feet. The abutment is made of concrete keyed into the apron. The apron key runs the length of the spillway. Sediment has filled in behind the spillway and prevents observations of the upstream face of the spillway. The downstream face is covered algae growth. Water has eroded the top layer of cement mortar and exposed the surface of the aggregate. No large cracks or spalls were observed during this inspection. Water flow and algae prevented small cracks from being observed. A stick probe did not reveal any scour pockets at the toe of the spillway.

b. Gate Structure 1

Gate Structure 1 is located approximately 120 feet east of the east abutment. The gate is not operable. The stone masonry of the outlet is in good condition. The mortar joints are starting to crumble. The inlet is mostly covered with debris. The outlet could not be located. The drawing indicates a 30-inch diameter pipe twenty-nine feet long. The extra width of the embankment indicates that the outlet has been buried by fill material. A seep at the bottom of the embankment indicates that the gate leak.

c. Gate Structure 2

Gate Structure 2 is adjacent to the east abutment. The stone and mortar are in fair condition. The gates are not operable. Vegetation is growing out of the mortar joints. Debris and sediment block the opening to the gates. The vegetation is so heavy that it was not possible to get a photo of the gates. The outlet is free of obstruction. Outlet stones are well aligned. The mortar joints in the outlet are in good condition. Both trenches are free of obstruction. The gate closest to the spillway has a significant amount of water flowing through it. The gate further away from the spillway has a very small amount of flow. The drawing indicates both trenches have 4-foot by 4-foot cross-section and a length of 22 feet.

c. Gate Structure 3

The drawing indicates a channel 200 feet east of the east abutment. The channel ran from the pond to the old mill. The channel no longer exists. The parking lot is continuous over the area where the channel and gate structure used to be. It is not possible to tell if the structure was removed or buried in place.

d. East Abutment

The east abutment is a concrete wall poured against the stone blocks of gate structure 2. There is a 7' long x 1.5' wide and 9" deep spall at the left end of the abutment. A moderate amount of abrasion has exposed the aggregate where the abutment joins the spillway. The downstream portion of the wall is in good condition. The stones are well bonded and aligned.

e. West Abutment

The overall condition of the west abutment is good. There is minor deterioration at the top surface of the abutment. Minor abrasion exposing the aggregate along the joint between the abutment and the spillway is present. There is graffiti on both crest and downstream areas of the wall. The stone portion of the wall is in good condition. The stones are well bonded and aligned. There is vegetation growing near the upstream end of the abutment. There is a water seep coming from the behind the toe of the abutment.

f. Apron

The apron is in overall good condition. The drawings indicate a 25'-0" wide concrete apron with a concrete toe and a line of piling at the upstream edge of the apron. There are no visible cracks or spalls. Thick algae growth and water flow prevented observations of small cracks and deficiencies. A stick probe along the toe did not reveal any scour pockets. There are gaps between the heavy riprap below the concrete apron. The probe felt like a gravel surface below the granite blocks. The lowest run of riprap block is no longer properly aligned.

2. RECOMEDATIONS

a. Gate Structure 2 should be rehabilitated for use during emergencies, inspections or construction projects. Clear settlement and vegetation from the structure and make the gates operational again. This will stop the water flow and prevent catastrophic failure of the gate.
b. Seal gate structure 1 to prevent seepage from eroding the embankment.
c. Clear heavy vegetation from the embankments.
d. Clear light vegetation from abutments and gate structures.

3. NORMAL MAINTENANCE ITEMS

a. Periodically remove debris from spillway and gates.
b. Periodic inspection program to maintain the dam's condition.

TEAM MEMBER CHECKLIST FOR INSPECTION		
AREA EVALUATED	**BY**	**CONDITION**
STRUCTURAL		
A. Spillway	DPC	
General Condition		Good, with minor to moderate surface abrasion at the crest.
B. Gate Structure		
General Condition		Poor and not operational.
Gate 1		Inlet is covered with silt and debris. The gate is not operable. The outlet is burried with fill. There is a water seep at the base of the embankment that indicated the gate leaks water.
Gate 2		Gates are not operable. Hardware is missing and needs to be replaced. Minor vegitation is growing in the joints. A 6" diameter tree has sprouted from the top of the structure. Minor debris inside of both outlet trenches. A large amount of water is passing through the gate closest to the abutment.
Gate 3		Covered with fill near the edge of the parking lot. Not possible to observe gate 3
Vegetation		There are many trees growing on the embankments. Smaller vegitation is growing from the structures. The vegitation should be removed.
B. Concrete Apron		
General Condition		Good condition, covered with algea growth. Well aligned. No signs of damage.
Heavy Riprap		Mostly in place and performing properly. Some blocks from the lowest run of riprap are out of place.

TEAM MEMBER CHECKLIST FOR INSPECTION		
AREA EVALUATED	**BY**	**CONDITION**
C. East Abutment	DPC	
General Condition		Fair large areas of deterioration. Concrete covering the stone is in place but sounds hollow. Hairline cracks with slight effloresence are present.
Spalls		7' long x 1'-6" wide x 9" deep spall at the corner of the wall
Condition of joints		Stone is well aligned. No signs of movement.
D. West Abutment.		
General Conditon		Fair, with minor to moderate abrasion at the joint with the spillway and apron. Hairline cracks with slight effloresence are present.
Spalls		Minor deterioration at the top surface of the wall.
Condition of joints		Good lignment of joints; no signs of movement of stones.
Vegitation		There are trees growing at the top and at the toe of the wall. The vegitation should be removed.

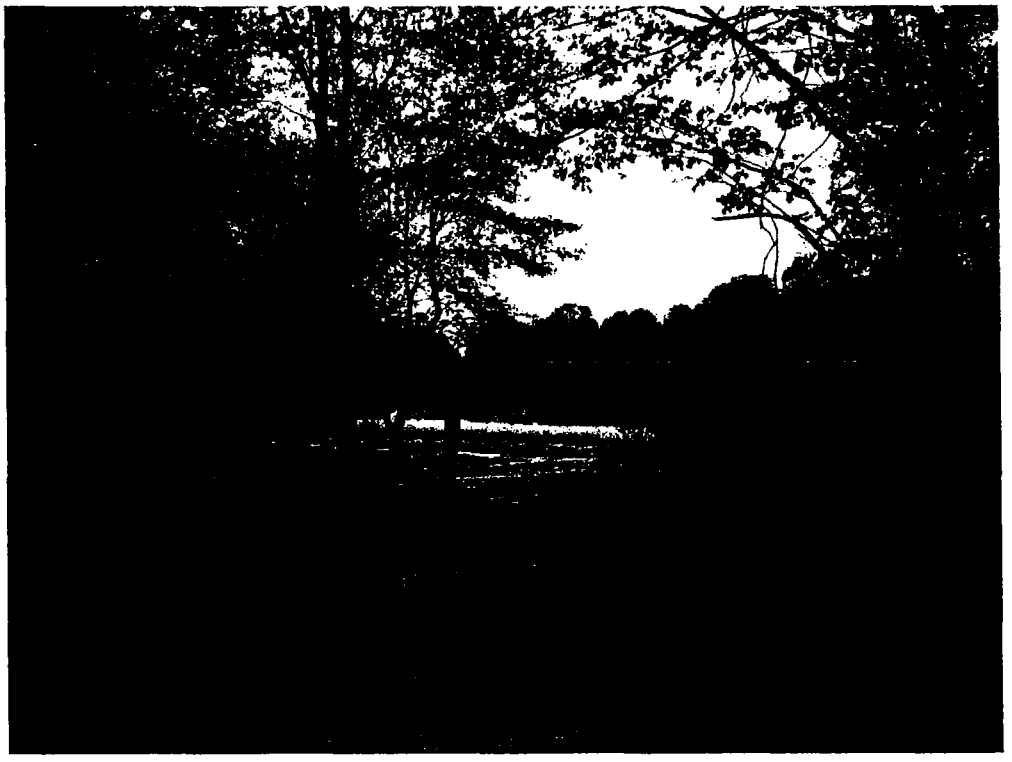

PHOTO 1: SPILLWAY

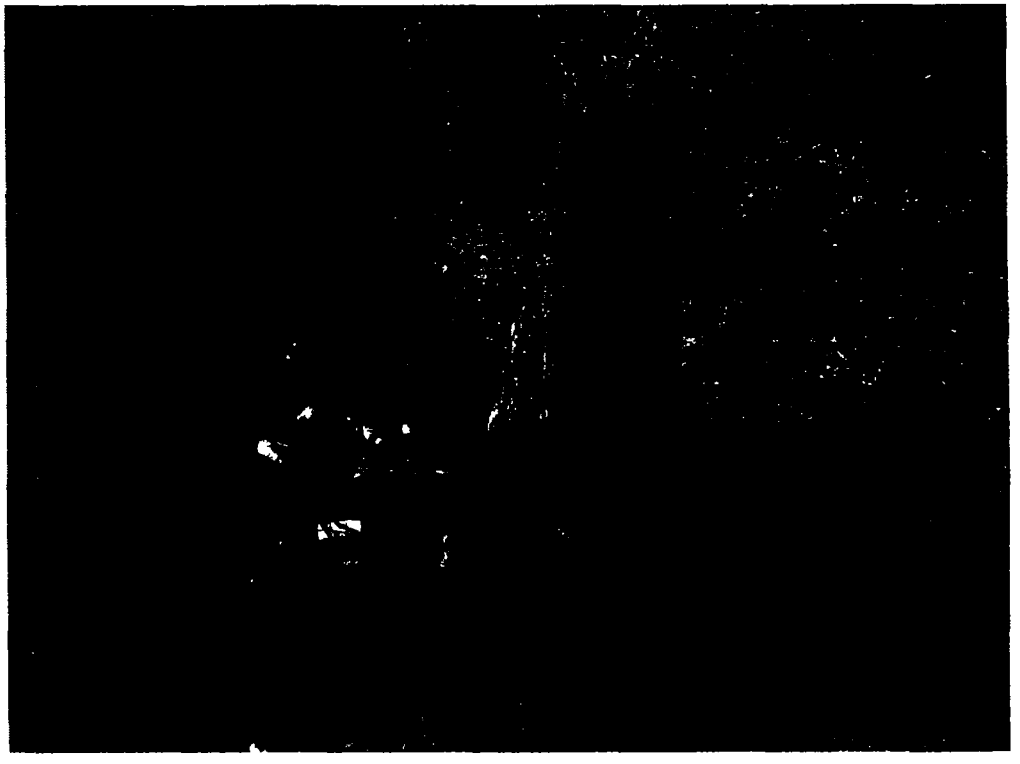

PHOTO 2: GATE STRUCTURE 1

PHOTO 3: GATE 2 OUTLET STRUCTURE

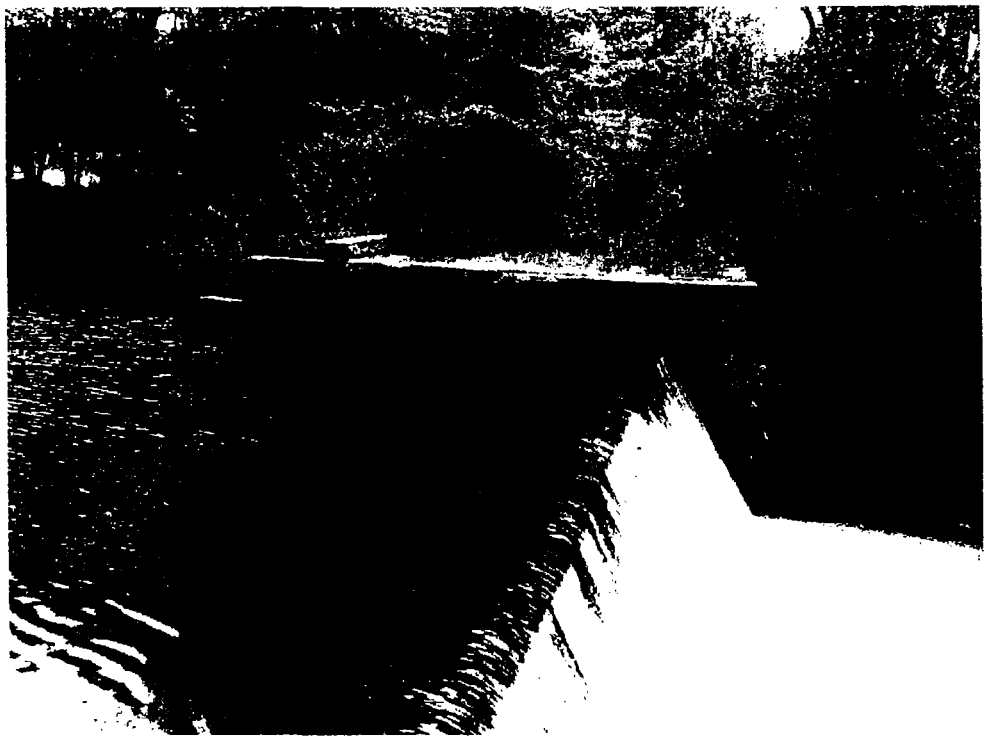

PHOTO 4: EAST ABUTMENT

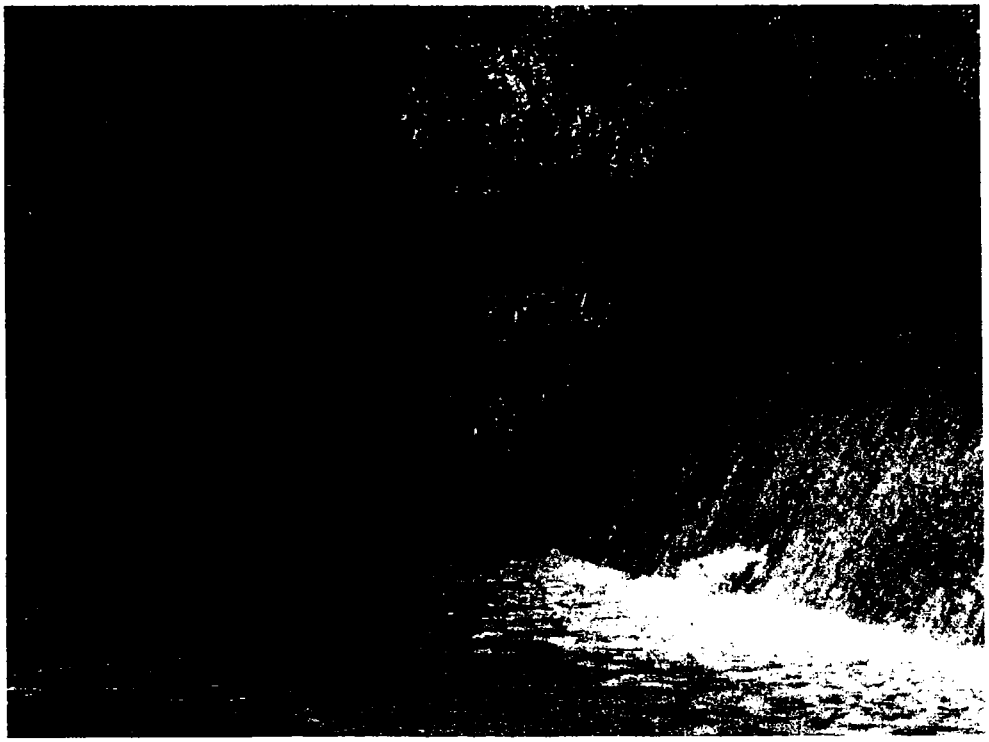

PHOTO 5: WEST ABUTMENT

PHOTO 6: APRON

ATTACHMENT 2

STRUCTURAL INSPECTION

MANTON DAM

MANTON DAM
WOONASQUATUCKET RIVER
NORTH PROVIDNCE, RHODE ISLAND

1. FIELD INSPECTION

David Cole from the Design Branch, Engineering/Planning Division of New England District of the Army Corps of Engineers, conducted the structural portion of the inspection of Manton Dam at North Providence, Rhode Island on 17 May 2005. Major features inspected are:

- Spillway
- Gate Structures
- East Abutment
- West Abutment
- Apron

Elevation and dimension used in this report are taken from a drawing provided by the State of Rhode Island. The drawing's title is "Manton Mills, American Woolen company Inc., Manton RI, Spillway. Drawing number Q-69-B. The drawing is dated 11-10-44.

a. Spillway:

The existing concrete spillway was poured directly in front of and existing timber crib structure. There is no visible evidence of the timber structure. The top of the spillway is approximately 85'-0" long and 2'-9" wide. The pond side face of the spillway is vertical. The downstream face of the spillway has a slope of 1:1. Total change in elevation from the crest of the dam to the top of the apron is 5'-0". Drawings indicate that the spillway is keyed into the spillway with a 6" deep and 2'-0" key.

Inspection showed minor to moderate surface abrasions and deterioration of the crest of the spillway. The abrasion has washed away the concrete mortar and exposed the face of the aggregate in the concrete. The surface of the spillway is covered with algae. Algae and water cascading down the face of the dam made it difficult to observe minor cracking of the spillway. There are no major deficiencies observed during this inspection.

b. Gate Structures

There is a pair of gates adjacent to the east abutment. Each gate is 4'-2" wide and 3'-6" high. The top of the opening is at elevation 97.75 ft. The gate structure is in poor condition and not operational. The gates have been removed, leaving corroded brackets behind. There are numerous areas of concrete deterioration around the gate stem opening. The west-training wall of the gate structure is the same as the east abutment wall. Two full height cracks, measuring up to ½" wide x 1'4" deep, are located in the east training wall leading to the gates. At the bottom of one of the cracks, the concrete is deteriorated with an aggregate face, up to 3" deep. There is an area of

deterioration, measuring 6' long x 4' wide x 1' deep, at the top of the slab of the gate structure. The outlet is blocked with fill and boulders. There is a significant amount of seepage through the gate. Water flow from the gates can be observed at the toe of the east abutment.

c. East Abutment

The overall condition of the east abutment is poor. There is a spall with exposed rebar starting at the upstream end of the wall that continues along the water line the length of the spillway. The concrete around the spall is unsound and severely abraded at the water line. There is a 2'-0" by 2'-0" triangular spall between the horizontal and vertical portions of the east abutment. Hairline cracks with minor efflorescence spider web across the spillway face of the wall. Erosion has undermined the upstream end of the east abutment.

d. West Abutment

The overall condition of the west abutment is good. The concrete facing over the existing stonewall has spalled off of the inside face of the wall for a length of approximately 10'-0", exposing the inner stone core. The stone core is well bonded and shows no signs of movement or deterioration. The facing is also missing for the full width of the wall and for 4'-0" +/- along the top surface of the wall. Otherwise, the concrete is sound and in good condition elsewhere along the wall. There is minor abrasion of the wall at the intersection with the spillway, both at the crest and on the downstream face.

e. Apron

The overall condition of the apron is good. No major cracks or scour holes. Minor cracks and spalls could not be observed due to the water flow and algae that covers the face of the abutment. The drawing indicate spillway dimensions of 1'-6" thick, 14'-0" width and 85'-0" length. There is a 1'0" by 1'-6" toe and a 1'-6" by 3'-0" heel under the apron.

Heavy riprap has been place below the tow of the apron. Probing the toe of the abutment and the toe of the riprap did not reveal any scour pockets larger then 1'-0" in depth.

2. RECOMMENDATIONS

a. Repair the east abutment. Replace the missing concrete. Remove and replace any unsound concrete. Repair the cracks.
b. Replace the gates and their support structure. The flow through the gate will be stopped. New gates will facilitate operations during emergencies, inspections and future construction/repair operations.

3. NORMAL MAINTENANCE ITEMS

a. Periodically remove debris from the spillway.
b. A regular monitoring and inspection program should be implemented to insure the continued deterioration of the east abutment does not be come critical before repairs can be made.
c. Clear vegetation growing in and around the gate outlet and the abutments.
d. Clear large vegetation from the earth embankments.

TEAM MEMBER CHECKLIST FOR INSPECTION		
AREA EVALUATED	**BY**	**CONDITION**
CONCRETE / STRUCTURAL		
A. Spillway	DPC	
General Condition		Good, with minor to moderate surface abrasion and deterioration of the crest
B. Gate Structure		
General Condition		Poor and not operational. Gates have been removed and the brackets that used to hold the gates are corroded beyound use.
Spalls		Numerous areas of concrete deterioration around the gate stem opening. An area of up to 3" deep is located at the bottom of the east training wall. A spall measuring 6' long x 4' wide and 1" deep is located at the top of the slab.
Debris		Fill and Boulders have covered the outlet.
Vegetation		There is grass and small trees growing at the top of the outlet works.
B. Concrete Apron		
General Condition		Good condition, covered with algea growth. Well aligned. No signs of damage.
Heavy Riprap		Mostly in place and performing properly.

TEAM MEMBER CHECKLIST FOR INSPECTION		
AREA EVALUATED	**BY**	**CONDITION**
C. East Abutment	DPC	
General Condition		Poor, large areas of deterioration. Concrete support is missing.
Spalls		Numrous areas of concrete deterioration around the gate stem opening. A full depth area of deterioration is located at the bottom of the east training wall. Rebar is exposed. Gravel from the original wall is visible. A spall, measuring 6' lond and 4' wide and 1' deep loacated at the top of the slab.
Debris		Gate outlet is block with boulders and fill.
D. West Abutment.		
General Conditon		Good. Minor abrasion has exposed the aggregate at the intersection between the west abutment and the spillway. The section directly above the spillway does not have a concrete cover. The mortar joints between the exposed stone are in good condition. Some stones are missing from the top of the wall.
Spalls		Concrete facing covering the original stone abutment has spalled away exposing 10' of wall. Concrete is also missing from the entire horizontal portion fo the west abutment.
Vegetation		There is vegetation growing at both upstream and downstream ends of the abutment.

PHOTO 1: SPILLWAY

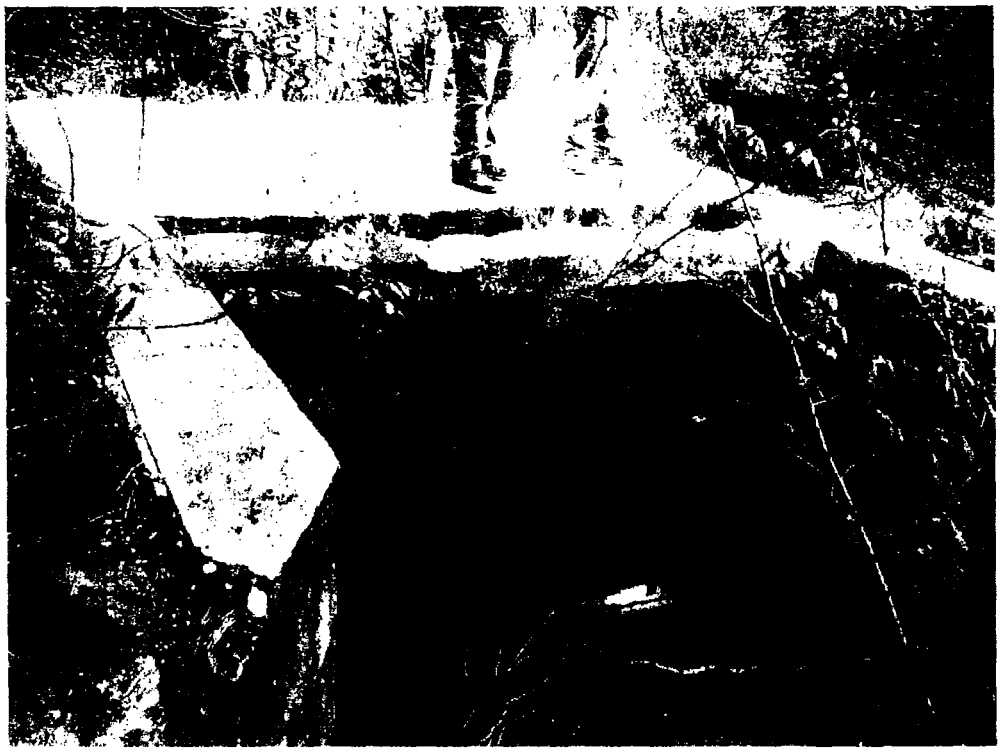

PHOTO 2: GATE STRUCTURE

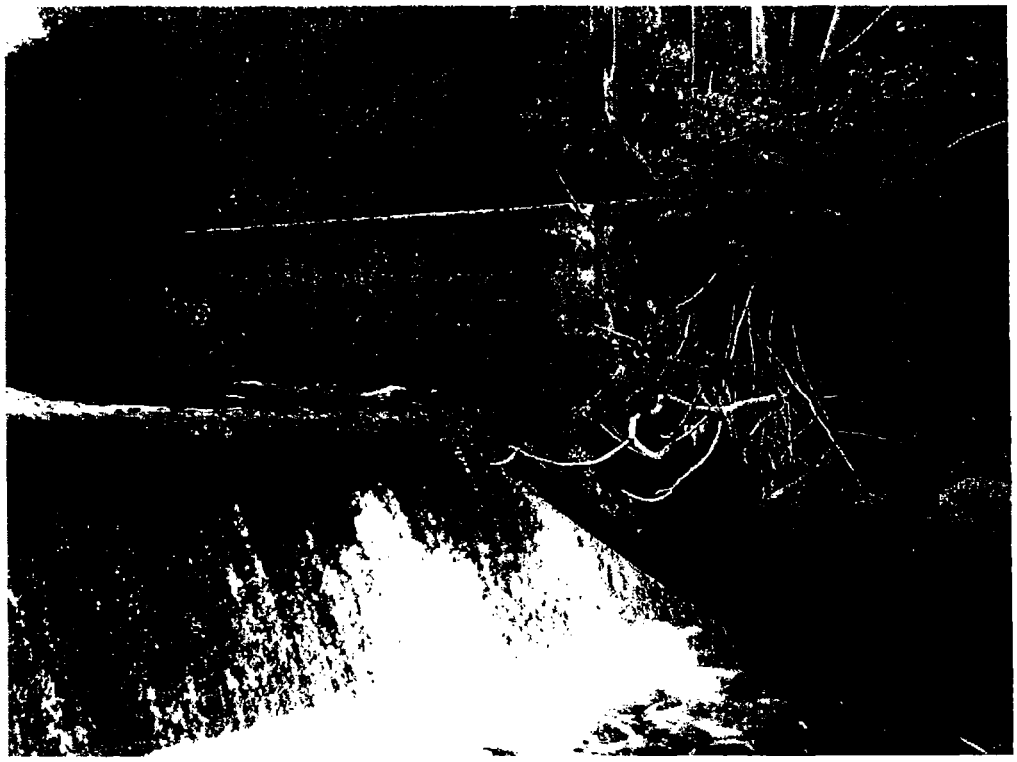

PHOTO 3: EAST ABUTMENT

PHOTO 4: WEST ABUTMENT

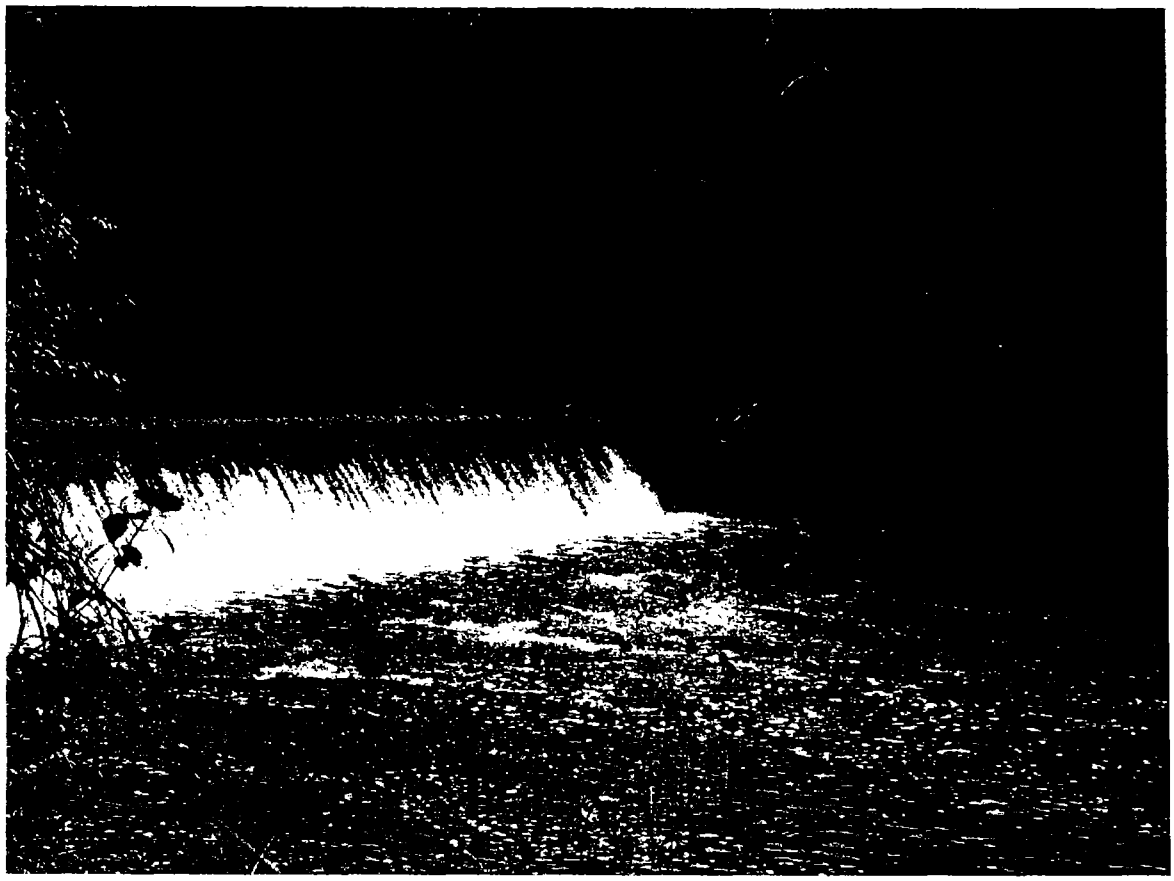

PHOTO 5: APRON

Townsend Bakers

Woonasquatucket River Dam Investigations
Rhode Island

August 1999

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of Engineers

New England District

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13. ABSTRACT *(Maximum 200 words)*

At the request of the state of Rhode Island, the Corps sent a team of specialists to inspect Lymansville, Manton, Atlantic Mills, Paragon, and Rising Sun Dams on April 27 and 28, 1999. These dams are on the Woonasquatucket River in Providence and North Providence . Dioxin-contaminated sediments had been found behind these dams, and state and community officials in Rhode Island were concerned they might fail and spread these contaminants. In addition to inspecting these dams, the Corps performed cursory hydrologic and hydraulic analyses of the spillways to evaluate the increased risk of dam failure during certain floods. Rhode Island does not have its own criteria for dams, so spillway capacities were compared to Corps criteria and the 100-year flood. The Corps also, at Rhode Island's request, performed a cursory evaluation of the capacity of the spill-way at Stillwater Reservoir, although the dam was not inspected for this report.

This report contains a narrative description of observations and recommendations, checklists of geotechnical, structural, and hydraulic features, and photographs taken dur-ing the inspection. Included costs for recommended work at these dams are very rough estimates.

14. SUBJECT TERMS
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CONCORD, MASSACHUSETTS

WOONASQUATUCKET RIVER DAM INVESTIGATIONS
RHODE ISLAND

JUNE 1999

WOONASQUATUCKET RIVER DAM INVESTIGATIONS
RHODE ISLAND

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APPENDIX A – LYMANSVILLE DAM
APPENDIX B – MANTON DAM
APPENDIX C – ATLANTIC MILLS DAM
APPENDIX D – PARAGON DAM
APPENDIX E – RISING SUN DAM

WOONASQUATUCKET RIVER DAM INVESTIGATIONS
RHODE ISLAND

1. PURPOSE AND SCOPE

At the request of the state of Rhode Island, the Corps sent a team of specialists to inspect Lymansville, Manton, Atlantic Mills, Paragon, and Rising Sun Dams on April 27 and 28, 1999. These dams are on the Woonasquatucket River in Providence and North Providence (see figure 1). Dioxin-contaminated sediments had been found behind these dams, and state and community officials in Rhode Island were concerned they might fail and spread these contaminants. In addition to inspecting these dams, the Corps performed cursory hydrologic and hydraulic analyses of the spillways to evaluate the increased risk of dam failure during certain floods. Rhode Island does not have its own criteria for dams, so spillway capacities were compared to Corps criteria and the 100-year flood. The Corps also, at Rhode Island's request, performed a cursory evaluation of the capacity of the spillway at Stillwater Reservoir, although the dam was not inspected for this report.

This report contains a narrative description of observations and recommendations, checklists of geotechnical, structural, and hydraulic features, and photographs taken during the inspection. Included costs for recommended work at these dams are very rough estimates.

The Corps inspection team included Mr. Paul Schimelfenyg who examined geotechnical features, Ms. Jennifer Lee who examined concrete and structural features, and Mr. Townsend Barker who examined hydraulic features. Mr. Paul Guglielimino from the Rhode Island Department of Environmental Management (RIDEM) accompanied them.

2. SUMMARY

Based on visual inspections, these dams are in generally fair condition and do not show signs of immediate danger of dam failure. However, all suffer from lack of maintenance and will continue to deteriorate if neglected.

None of the spillways meet Corps of Engineers hydrologic criteria for spillway design (i.e. full or half PMF). To provide information on spillway capacity relative to more frequent floods, conditions during the 100-year flood were evaluated; however, this does not imply Corps endorsement of the 100-year flood for spillway design. These analyses show that backwaters during the 100-year flood reduce water surface elevation differences across the five dams to less than those that occur during normal flow conditions; consequently, the dams are not likely to fail catastrophically during floods up to the 100-year. However, overtopping of earth embankments at Lymansville and Manton Dams and a masonry abutment in poor condition at Atlantic Mills Dam could result in rapid erosion of the earth embankments or failure of the masonry abutment, leading to washout of

Woonasquatucket River Dams
Inspected in April 1999

sediments from behind these dams.

The 1981 Phase I inspection classified Stillwater Reservoir dam as a high hazard, intermediate size project, and Corps guidelines call for such projects to be able to pass the probable maximum flood (PMF). Stillwater Dam's spillway can pass neither the PMF nor the half PMF, although it can pass the 100-year flood with 0.4 feet of freeboard. Detailed design studies by Rhode Island should refine the PMF analysis to get a more accurate number than that used in the Phase I report, which used rule-of-thumb guidelines and did not consider factors such as backwater effects.

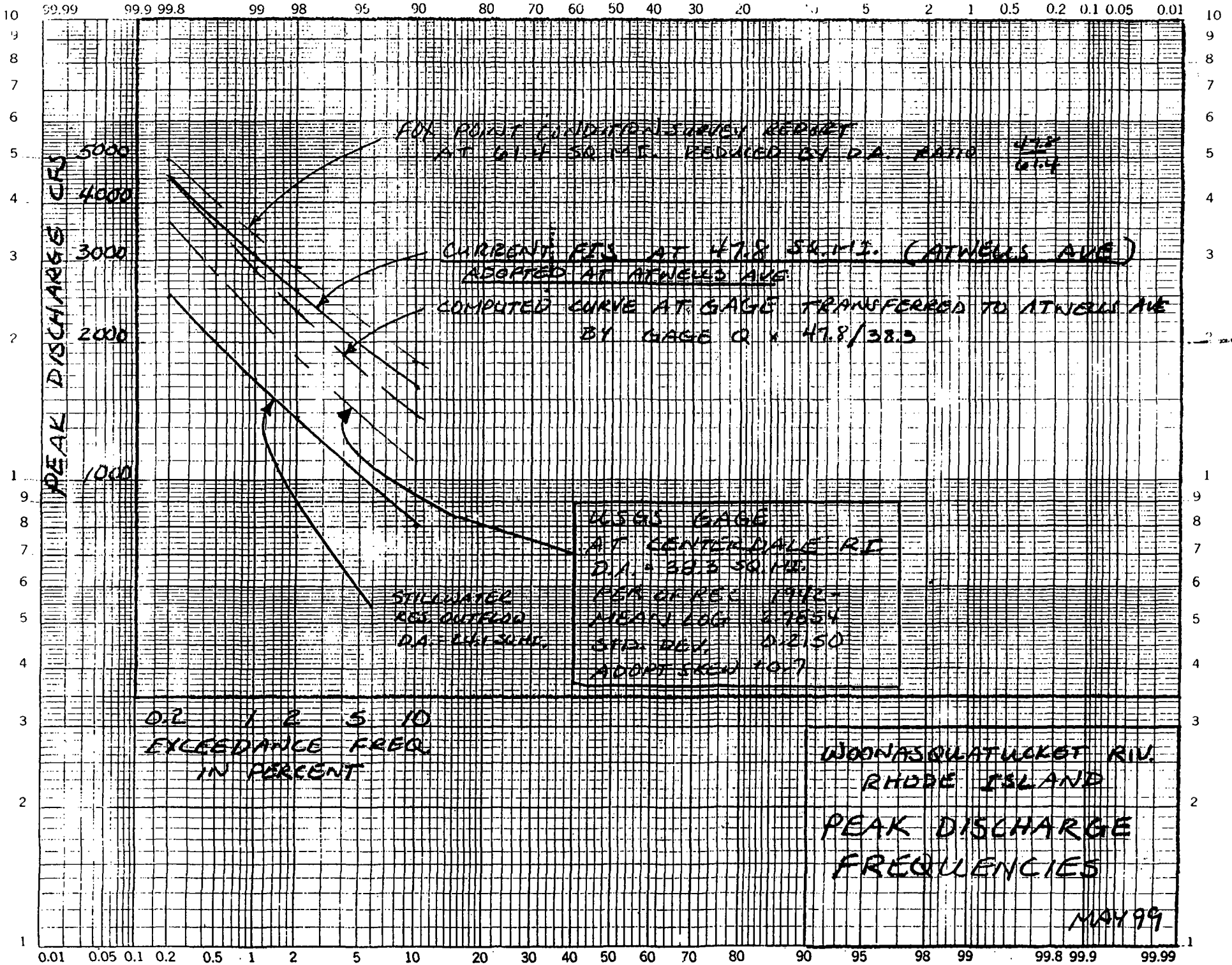
3. HYDROLOGIC AND HYDRAULIC ANALYSES

a. Introduction. As part of the inspection of the Woonasquatucket River dams requested by Rhode Island, the Corps performed cursory hydrologic analyses of the watershed and hydraulic analyses of the spillways to evaluate potential hydrologic deficiencies that may increase the risk of dam failure during floods. Rhode Island is only in the preliminary stages of developing its own criteria for spillway capacities. Consequently, the Corps used its own criteria, but also examined the 100, 50, and 10-year floods. Appendices A through E contain more detailed descriptions of hydrologic and hydraulic analyses for each of the five inspected dams. Section 4 f. of this report describes the spillway analysis for Stillwater Reservoir dam.

b. Hydrologic Analyses. Discharge frequencies for the dams were evaluated using the USGS gage record, FEMA flood insurance studies, and the Corps condition survey report for the Fox Point Hurricane Barrier. As shown in figure 2, these gave similar results, especially for the rarer events, with the flood insurance study results falling between the other two and, therefore, being adopted as reasonable estimates for this study. For the lower 3 dams, 10, 50, and 100-year flood discharges were taken from the Providence, Rhode Island flood insurance study results for Atwells Avenue; for Lymansville and Manton—the upper two dams—discharges were taken from the results for the Providence-North Providence border.

The USGS Woonasquatucket River gage at Centerdale, Rhode Island has been in operation since 1942 and has 56 years of flow data available. This data was analyzed with a log Pearson type III distribution in accordance with procedures presented in Water Resources Council Bulletin number 17B. Results gave a mean log of 2.7554, standard deviation of 0.215, and a computed skew of –0.07. A regional skew of 0.7 was adopted based on information in Bulletin 17B. Computed peak discharges for various frequencies were then transferred downstream by drainage area ratio. Computed and adjusted discharges are plotted in figure 2.

Discharge frequencies from the Providence, Rhode Island flood insurance study are also plotted on figure 2. The location selected for comparison was at Atwells Avenue, which has a drainage area of 47.8 square miles and is in the general vicinity of the lower


PEAK DISCHARGE CFS
5000
4000
3000
2000
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99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 5 2 1 0.5 0.2 0.1 0.05 0.01
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
FOR POINT CONTROL SURVEY REPORT
AT 61.4 SQ. MI. REDUCED BY D.A. RATIO 47.8/61.4
CURRENT FES AT 47.8 SQ.MI. (ATWELLS AVE)
ADOPTED AT ATWELLS AVE
COMPUTED CURVE AT GAGE TRANSFERRED TO ATWELLS AVE
BY GAGE Q x 47.8/38.3
USGS GAGE
AT CENTERDALE RD
D.A. = 38.3 SQ.MI.
PER OF REC. 1912-
MEAN LOG 2.7654
STD. DEV. 0.2150
ADOPT SKEW 1.0
STILLWATER
RES. OUTFLOW
D.A. = 41.3 SQ.MI.
0.2 1 2 5 10
EXCEEDANCE FREQ.
IN PERCENT
WOONASQUATUCKET RIV.
RHODE ISLAND
PEAK DISCHARGE
FREQUENCIES
MAY 99

Figure 2

four dams.

Lastly, the April 1998 condition survey report for the Fox Point Hurricane Barrier was reviewed. The Corps recently completed this report as part of an evaluation of the need to rehabilitate the Fox Point project. It includes an update of peak discharge frequencies at the barrier and a point upstream where the Providence River (whose main tributary is the Woonasquatucket) has a drainage area of 61.4 square miles. Discharges at the latter location were reduced by drainage area ratio to the Atwells Avenue location, and are plotted in figure 2.

Results show generally good agreement between the three methods. The adjusted Fox Point condition results were on the high end and adjusted USGS gage results were on the low end with FEMA flood insurance study results in between.

c. Hydraulic Analyses. Results of hydraulic analyses were very approximate, and while suitable for the purposes of this study, they should not be considered definitive. Survey data was available only for Rising Sun, Paragon, and Atlantic Mills Dams. Analyses of spillways and outlet works for Lymansville and Manton Dams were based on dimensions from old drawings supplemented by a few measurements during the field inspections. Hydraulic analyses were limited to hand calculations; no computer modeling of the river, or calibrations to high water marks were included.

4. FINDINGS AND RECOMMENDATIONS

a. Lymansville Dam.

(1) General Observations. The first dam inspected on 27 April was Lymansville, located in North Providence and Johnston, about ½ mile upstream from the Providence-North Providence border (see figure 1). Overall condition of the dam was fair. We had good access to both sides of the dam, but had difficulty inspecting the embankments because of the heavy vegetation. It is an earth embankment dam with a concrete-faced spillway and granite block outlet works. Embankments were overgrown with trees and brush, and eroded from foot trails and runoff, but there were no signs of settlement, lateral movement, sloughing of slopes, or significant instability. Abutments were in fair to good condition with some abrasion and spalling of concrete. We did not observe any seepage at the toe of the embankments or abutments, but heavy vegetation impeded inspections. A natural wetland at the base of the dam also helped obscure signs of possible seepage. Outlet works were in poor condition and not operable. About 1 inch of water was flowing over the spillway and preventing observations of leakage through the spillway and the condition of the spillway face; however, it appeared to be in generally fair condition. River flow prevented inspection of the concrete apron and downstream flagstones, but they appear to be in fair to good condition. Although the embankment crest is about 30 feet wide, vehicular access along the dam crest is poor because of heavy vegetation and an eroded surface. The Lymansville Dam appendix contains copies of photo-

graphs taken during the April 1999 inspection.

(2) Available Information. Available information on this dam came from RIDEM and includes plans prepared by O. Perry Sarle for the Tucker Construction Co. in August 1936, and drawings of the dam prepared by the WPA in November 1940. The general features and dimensions of the dam observed in the field matched those in the drawings. These show the dam as being an earth embankment with a granite block spillway with concrete facing. The spillway discharges to a 15.5-foot long concrete apron followed by 3 rows of heavy riprap. Sarle's drawings show 4-inch by 16-foot planks driven into blue clay as a cutoff wall underneath the spillway. The downstream face of the spillway slopes at 2 vertical to 1 horizontal, there is a gentle approach slope on the upstream side. Two outlet gates are located at the left side of the spillway, and a second gate at the left end of the dam. The plans show a triple gated outlet in a trench on the left bank. Outlet works are constructed of masonry blocks. Dimensions and elevations from the WPA drawing are in the hydrology and hydraulics section of the Lymansville Dam appendix.

(3) Embankments. The east and west dam embankments are in fair condition. The horizontal and vertical alignments of the crest, slopes and toes are very irregular due to significant runoff and pedestrian erosion. Many eroded channels and areas up to three feet deep were noted in the crests and slopes. However, there was no evidence of settlement, lateral movement, sloughing of slopes, or significant instability, that would affect the performance of the earth embankments.

Heavy vegetation and debris cover the embankments completely except for narrow paths along the crests to the spillway area. Trees up to 24 inches in diameter and 60 feet tall, as well as brush, are growing all over the embankments. A few trees have toppled, and soil around the remaining root holes is very susceptible to erosion. Some soil has turned an orange color due to oxidation. Wetland vegetation and soils (peat and organic silt) were noted in the downstream toe areas. Construction debris and trash covered approximately 25 percent of the east embankment.

(4) Abutments. The abutments are in fair to good condition. Only a small amount of erosion was noted at the abutments except for the west abutment of the spillway where an approximately 2-foot deep by 8-foot by 8-foot deep eroded area was observed. Excessive vegetation was growing on all the abutments.

(a) East Abutment Wall. There is a 7-foot long by 1-foot 6-inch wide by 9-inch deep spall at the corner of the east (left) concrete abutment of the spillway, which is cast against the stone masonry of the gate structure. There is minor to moderate abrasion of the wall at the intersection with the spillway, both at the crest and on the downstream face. The downstream stone portion of the wall is in good condition, and the stones are well bonded and aligned.

(b) West Abutment Wall. The overall condition of the west (right) concrete wall is good. There is minor deterioration at the top surface of the wall. Minor to moderate abrasion, similar to the east wall, is noted at the west abutment wall. There is graffiti on the entire surface of the wall, both at the crest and downstream of the spillway. The stone portion of the wall is in good condition, and the stones are well bonded and aligned.

(5) Seepage. Seepage emergence (piping or boils) was not observed at the downstream toe of the embankments, on the downstream slope, or at the abutments. Vegetation and debris on the embankment crests, slopes, toes, and abutments made it difficult to assess possible seepage problems. Flow over the spillway prevented observations of seepage at its toe.

(6) Outlet Works. . The outlet works were in poor conditions and not operable. Three gate structures are shown through the east embankment of the dam on the design plans, but only the west and central gates were found. The east gate was either removed or buried under a parking lot; we assumed it was properly filled in. The inlet channels to the west and central gates were inundated and partially clogged with debris. The west outlet gates, on the left side of the spillway, appeared to be closed with 100-200 gpm leakage. The stone masonry of the outlet is in good condition. The stones are well bonded and aligned properly, however, there is minor vegetation growing in the joints. There does not appear to be any movement of the stones. The discharge channel was clear. The central outlet works, on the left side of the dam, were in very poor condition, and the outlet was not visible and probably buried under earth fill.

(7) Crest Roads. Access along the crest of the embankments is poor, although the crest widths are approximately 30 feet wide and they appear to be surfaced with mainly granular materials. Heavy vegetation restricts the access width at both embankments to little more than hiking trails. Erosion has left the crest surface extremely uneven and irregular.

(8) Spillway. The spillway consists of concrete-faced granite blocks, a concrete apron with a stone surface, and east and west abutment walls. The spillway appears to be in good condition. There is minor to moderate surface abrasion and deterioration at the crest of the spillway. The remains of flashboard anchors were observed about every 10 feet along the crest. The approach and discharge channels are natural river channel. They are clear of vegetation, debris and rocks. A section of tree trunk was caught on the top left side of the spillway, but otherwise, it was free of debris or obstructions to flow. Sediment has filled in behind the spillway. Water flowing over the spillway prevented observation of the condition of its downstream face. The spillway apron appeared to be in fair to poor condition, but flowing water greatly limited observations. There was significant displacement and undermining of the concrete at the apron's downstream end. Immediately downstream of the apron, the large flagstones placed in the channel do not show any signs of past significant movement and appeared to be in good condition.

(9) Spillway Capacity. The Lymansville Dam spillway has a capacity of about 3,000 cfs, and can pass the 100-year discharge with about 0.4 feet of freeboard between the water surface and the top of the dam. A backwater reaches part way up the base of the dam during the 100-year discharge, but does not reach the spillway crest. As a result of this backwater, total head difference across the dam is less during the 100-year flow than it is during normal flow conditions. Consequently, sudden catastrophic failure of the dam during the 100-year flow is unlikely. However, there are portions of the embankment crests that are eroded and may be two feet or more below the elevation of the abutment walls. During the 100-year flood, water flowing over these unprotected sections could lead to rapid erosion of the embankment followed by possible washout of sediments behind the dam. Additional information on the determination of flood frequencies and spillway capacity is in the hydrology and hydraulics section of the Lymansville Dam appendix.

(10) Recommendations. To help insure continued adequate performance of the dam, debris and excess vegetation should be removed from the dam, and toe, slope and crest protection should be placed immediately. In addition, the outlet works should be repaired or replaced to allow the pool behind the dam to be lowered for inspection, repairs, or an emergency, and deteriorated concrete should be patched or repaired. A regular monitoring program should be implemented to check for movement or shifting of the dam.

(a) Vegetation. Brush and tree growth, including the root systems, should be removed from the embankment toes, slopes, crests, and abutments. A sufficient clearance (greater than ten feet) should be provided along the downstream toes and abutments for access and to observe possible seepage. Root holes remaining after the removal operation should be filled with compacted materials similar to those used in original embankment construction. Estimated cost: $40,000.

(b) Debris. All debris should be removed from the embankments, abutments, and inlet and outlet channels. It should be disposed of properly off site. Estimated cost: $10,000.

(c) Toe, Slope and Crest Protection. After vegetation removal and backfilling root holes, the embankment crest should be raised to the abutment elevations or higher at all points, and properly sized stone underlain with a bedding/filter layer should be placed in areas normally inundated with water and two feet above. Grass should be established in the remaining areas and mowed periodically. Estimated cost: $100,000.

(d) Outlet Works. The gates and associated lifting mechanisms should be replaced to make the gate structure operational for use during emergencies, inspections, and repairs. Estimated cost: $40,000.

(e) Concrete Repairs. Repair the areas of concrete deterioration at the

spillway and all appurtenant structures. Estimated cost: $3,000.

b. Manton Dam.

(1) General Observations. The second dam inspected on 27 April was Manton Dam on the Providence-Johnston border, about ¼ mile downstream of the Providence-North Providence line (see figure 1). The dam was in generally fair condition. We had good access to both sides. It is an earth embankment dam with a concrete spillway. The embankment was overgrown with trees and brush, and had many eroded channels in the crest and slopes, but there were no signs of settlement, lateral movement, sloughing of slopes, or significant instability. Abutments were in fair to good condition with some spalling of concrete. We did not observe any seepage at the toe of the embankment or abutments, but heavy vegetation impeded inspections. Outlet works were in poor condition and inoperable. Water flowing over the spillway prevented observations of leakage through the spillway and the condition of the spillway face; however, it appeared to be in generally good condition. The Manton Dam appendix contains copies of photographs taken during the April 1999 inspection.

(2) Available Information. Available information on this dam came from RIDEM and includes drawings prepared by the WPA in November 1940, and a blueprint prepared by O. Perry Sarle in November 1944 for spillway concrete reinforcement. The general features and dimensions of the dam observed in the field match those in the drawings. These plans show the dam as being an earth embankment with a concrete spillway. The 1940 plans show the spillway having a vertical downstream face with a 12" by 12" timber at its crest and 4" of flashboards on top of that. The 1944 blueprints show a new concrete spillway being built at the downstream face of the old one. This new spillway has a top length of 2' 9" and a downstream face with a slope of one horizontal to 1.5 vertical. The spillway discharges to an 8.5 foot wide concrete apron followed by heavy riprap. Drawings show concrete outlet works on the left end of the spillway with two discharge conduits. The WPA drawing shows a gated water intake on dam's left side. Elevations from the WPA and Sarle drawings are in the hydrology and hydraulics section of the Manton Dam appendix.

(3) Embankments. The west dam embankment is in fair condition. The horizontal and vertical alignments of the crest, slopes and toes are very irregular due to significant runoff and pedestrian erosion. Many eroded channels and areas up to three feet deep were noted in the crest and slopes. However, there was no evidence of settlement, lateral movement, sloughing of slopes, or significant instability, that would affect the performance of the earth embankment.

Heavy vegetation and debris cover the embankments completely except for narrow paths along the crests to the spillway area. Trees up to 18 inches in diameter and 50 feet tall, as well as brush, completely cover the embankments. Wetland vegetation and soils (peat and organic silt) were noted in the downstream toe areas.

(4) Abutments. The abutments are in fair to good condition. A small amount of erosion was noted at the abutments, and primarily at the east abutment. Stone protection up to five feet in diameter has been placed along the east abutment but underlying material is being eroded due to lack of filters. Excessive vegetation grew in both abutments.

(a) West Abutment Wall. The overall condition of the west (right) abutment wall was good. The concrete facing over the existing stone wall has spalled off on the inside face of the wall for a length of approximately 10 feet, exposing the inner stone core. The stone core was well bonded and shows no signs of movement or deterioration. The facing was also missing for the full width of the wall and about 4 feet long on the top surface of the wall. Otherwise, the concrete was sound and in good condition. There was minor abrasion of the wall at the intersection with the spillway, both at the crest and on the downstream face.

(b) East Abutment Wall. The overall condition of the east (left) concrete wall was fair to good. There was a spall with exposed rebar, measuring 6 feet long by 3 feet high by 1 foot 4 inches deep at the upstream/leading end of the wall. The concrete around this spall was unsound and severely abraded at the waterline. Otherwise, the concrete abutment wall was generally in good condition.

(5) Seepage. Seepage emergence (piping or boils) was not observed at the downstream toe of the embankment, on the downstream slope, or at the abutments. The existing vegetation and debris on the embankment crest, slopes, toes, and abutments made it difficult to assess possible seepage problems. Flow over the spillway prevented observations of seepage at its toe.

(6) Outlet Works. Two gate structures are shown at the east end (left side) of the spillway on the design plans. Only the outlet works discharging to the river were observed during the inspection. The water supply intake was either removed or completely buried under earth fill.

The remaining gate structure was in poor condition and not operational. The gates have been removed, leaving corroded brackets behind. There were numerous areas of concrete deterioration around the gate stem opening. Two full height cracks, measuring up to ½ inch thick by 16 inches deep, were located in the east training wall leading to the gates. At the bottom of one of the cracks, the concrete was deteriorated with an aggregate face, up to 3 inches deep. There was an area of deterioration, measuring 6 feet long by 4 feet wide by 1 inch deep, at the top of the slab of the gate structure. The outlet channel for the gate structure has been filled with soil and stone. The inlet channel was inundated and partially clogged with debris.

(7) Crest Roads. Access along the crest of the embankment is fair. The crest width is approximately 10 feet wide. It appears to be surfaced with mainly granular

materials. However, heavy vegetation encroaches on the crest and limits its useable width. The erosion discussed above has left the crest surface extremely uneven and irregular.

(8) Spillway. The spillway consists of a concrete structure built in front of an existing concrete wall with a 12 inch by 12 inch timber cap, concrete apron, and east and west abutment walls. The spillway appeared to be in good condition. The natural river forms the approach and discharge channels. They were clear of vegetation, debris, and rocks. A large island was situated approximately 100 feet upstream of the dam but did not seem to impact operation of the dam. Some tree branches were caught at the timber beam of the old spillway wall, otherwise, there were no obstructions to flow.

There was minor to moderate surface abrasion and deterioration of the crest of the spillway. Water flowing over the spillway prevented observation of the condition of the downstream face of the spillway. The condition of the apron was not observable due to the rapid flow of the water down the spillway. Heavy riprap placed immediately downstream of the apron was submerged.

(9) Spillway Capacity. Manton Dam's spillway has a capacity of about 1,500 cfs, and can pass the 15-year discharge without overtopping the dam. A backwater reaches the spillway crest during the 80-year flood and submerges it about 0.6 feet during the 100-year event. This backwater only slightly reduces spillway capacity during the 100-year discharge. The dam would be overtopped by an estimated 1.35 feet during the 100-year flood, but the difference in water surface elevations above and below the dam would be less than 3.8 feet because of backwater effects, and a sudden catastrophic failure would be unlikely. However, water flowing over the earth embankment could lead to rapid erosion of the dam and washout of sediments behind it. Additional information on the determination of flood frequencies and spillway capacity is in the hydrology and hydraulics section of the Manton Dam appendix.

(10) Recommendations. To help insure continued adequate performance of the dam, debris and excess vegetation should be removed from the dam, and toe, slope and crest protection should be placed immediately. In addition, the outlet works should be repaired or replaced to allow the pool behind the dam to be lowered for inspection, repairs, or an emergency, and deteriorated concrete should be patched or repaired. A regular monitoring program should be implemented to check for movement or shifting of the dam.

(a) Vegetation. Brush and tree growth, including the root systems, should be removed from the embankment toes, slopes, crests, and abutments. A sufficient clearance (greater than ten feet) should be provided along the downstream toes and abutments for access and to observe possible seepage. Root holes remaining after the removal operation should be filled with compacted materials similar to those used in original embankment construction. Estimated cost: $8,000.

(b) Toe, Slope and Crest Protection. After vegetation removal and backfilling of root holes, properly sized stone underlain with a bedding/filter layer should be placed in areas normally inundated with water and two feet above. The earth embankment should be raised to at least the elevation of the abutment wall. Grass should be established in the remaining areas and mown periodically. Estimated cost: $13,000.

(c) East Abutment. The large spall at the east abutment wall should be repaired, and all other areas of concrete deterioration should be identified and repaired with a concrete repair mortar. The two cracks should be repaired. A properly engineered and designed filter system should be placed under the existing stone protection. Construction of the filter system would require removal and replacement of the stone protection. Estimated cost: $21,000.

(d) Outlet Works. The gates, along with all associated lifting mechanism, should be replaced and the gate structure operational for use during emergencies or inspections and repairs of the spillway. Estimated cost: $30,000

c. Atlantic Mills Dam.

(1) General Observations. The third dam inspected on 27 April was Atlantic Mills, located in Providence across the river and north from the intersection of routes 6 and 195 (see figure 1). The overall condition of the dam was fair. We had good access to both sides of the dam. The spillway makes up most of this masonry block dam. The south (right) abutment has partially collapsed, there is excessive vegetation growing on the dam, and the top of the south end of the dam may be tilting downstream; otherwise, the dam appears to be structurally sound. Outlet works were in poor condition and inoperable. The Atlantic Mills Dam appendix contains copies of photographs taken during the April 1999 inspection.

(2) Available Information. Available information on this dam came from a November 1940 WPA drawing from RIDEM, and survey data in a draft December 31, 1998 Battelle report to the Corps ("Hydrodynamic Modeling Site Survey, Woonasquatucket River, Providence, Rhode Island"). The general features and dimensions of the dam observed in the field match those in the WPA drawing and Battelle report. Where dimensions from the Battelle report did not agree with those in the WPA drawings, the more recent Battelle dimensions were used in the hydraulic analyses. Dimensions from the WPA and Battelle are in the hydrology and hydraulics section of the Atlantic Mills Dam appendix.

The WPA drawing shows a masonry dam with a 98-foot long spillway that makes up most of the dam. The spillway has a vertical downstream face and two 10 by 10-inch beams on top of the spillway except for the final 25 feet on the left hand side which has a single 10 by 10-inch and one 2 by 8-inch beam. As a result, the left 25 feet are 2 inches lower. The outlet works are on the right side of the spillway. A water intake

is depicted on the right-hand side of the dam. Elevations for the dam appeared to be based on arbitrarily setting the spillway to 50.0 feet, and were not equivalent to NGVD.

The Battelle report does not describe the dam, but gives elevations related to NGVD. It shows a total spillway width of 100.0 feet with a 37-foot section having a spillway crest elevation of 31.3 feet and a 63-foot section having a higher crest elevation of 32.2 feet due to wooden beams on the crest. The elevation of the right abutment wall is given as 35.2 feet while the left is 35.0 feet.

(3) Abutments. The abutments are in fair to poor condition. The south abutment wall has partially collapsed, and the collapsed portion is covered with debris. Excessive vegetation (brush and trees up to 24 inches in diameter and 50 feet tall) are growing in the south 25 feet of the dam and in the abutment walls.

(4) Seepage. Seepage emergence (piping or boils) was not observed at the dam abutments. The existing vegetation and debris at and along the abutments made it difficult to assess possible seepage problems. Flow over the spillway prevented observations of seepage at its toe.

(5) Outlet Works. The water intake shown on the WPA drawing was either removed or buried by earth fill in the parking lot. A gate structure between the spillway and the south abutment was visible but partially buried. The 12 foot by 12 foot outlet structure is in poor condition. The 5 foot 10 inch by 4 foot 6 inch opening was inundated and almost completely filled with debris. There were no signs of a previously existing gate. The downstream portion of the structure has been partially filled with soil, stone, and debris. Stacked stone blocks (no mortar between the joints) which make up the outlet structure have shifted and moved, up to 4 inches due to tree growth between the joints.

(6) Spillway. The 100-foot long spillway was made up of large stone blocks, creating a vertical downstream face. Up to the level of the spillway crest, the masonry was in fair to good condition. The spillway leads into the outlet structure at the right side and ends at a stone wall at the left (north) side. For 63 feet adjacent to the outlet structure, the spillway was topped off with a 10 inch by 10 inch timber and a large diameter tree trunk. According to the WPA drawing the remainder of spillway were topped with a 10 inch by 10 inch and a 2 inch by 8 inch timber. The top 10 by 10 timber at the right side was severely weathered and cracked. The tree trunk beneath it was in good condition. The 2 by 8 timber adjacent to the left abutment stone wall was missing, and all water over the dam was discharging through this section. Water was flowing through the gaps between the 10 by 10 timber and the tree trunk at the right side of the spillway. Otherwise, there was minimal leakage between the joints of the stone blocks. At the left abutment, the stone wall has shifted due to a large tree growing through the joint. Movement of up to 6 inches was noted. A large telephone pole and other minor tree debris were caught at the top of the right side of the spillway. Sediment has filled in behind the spillway.

Masonry walls line the channel for a short reach upstream of the dam and a long reach downstream. The upstream channel was clear of vegetation, debris or rocks. Two depositional areas were observed about 60 feet downstream of the dam in the middle of the channel and 10 feet downstream along the south abutment. Trees up to 18 inches in diameter and 60 feet tall were growing in the depositional areas. The river makes a right angle turn approximately 100 feet upstream of the dam that did not seem to impact operation of the dam.

(7) Spillway Capacity. The Atlantic Mills Dam spillway has a capacity of about 1,900 cfs, equivalent to the 15-year discharge. A backwater reaches the spillway crest during the 20-year discharge and submerges the dam during 100-year discharge. Because of this backwater, flow over the spillway would have to be 6.5 feet deep—about 2.8 feet over the top of the dam—to pass the 100-year discharge of 3,090 cfs. However, even though the dam would be overtopped, the difference in water surface elevations above and below the dam would be only 1.3 feet due to backwater effects; consequently, a sudden catastrophic failure would be unlikely. However, erosion could occur along the embankments and failure of the right (south) abutment is possible and could lead to washout of sediments behind the dam. Additional information on the determination of flood frequencies and spillway capacity is in the hydrology and hydraulics section of the Atlantic Mills Dam appendix.

(8) Recommendations. To help insure continued adequate performance of the dam, debris and excess vegetation should be removed and channel walls should be repaired immediately. In addition, the outlet works should be repaired or replaced to allow the pool behind the dam to be lowered for inspection, repairs, or an emergency. A regular monitoring program should be implemented to check for movement or shifting of the dam.

(a) Vegetation. Debris, brush and tree growth, including the root systems, should be removed from abutments, the channel walls in the vicinity of the abutments, and the depositional areas downstream of the dam. A sufficient clearance (greater than ten feet) should be provided along the abutments for access and to observe possible seepage. Root holes remaining after the removal operation should be filled and repaired with materials that match conditions adjacent to them. Estimated cost: $16,000.

(b) Channel Walls. The channel walls in the vicinity of the abutments should be repaired. Shifted and displaced stone blocks should be restored to their proper positions. Estimated cost: $10,000

(c) Outlet Works. The outlet structure opening should be cleaned out and a gate installed to be used during emergencies or inspections and repairs of the spillway. Estimated cost: $20,000

(d) Spillway Timbers. The top 10 by 10 timber and the 2 by 8 timber should be replaced if it is desired to maintain the design elevation of the spillway.

Estimated cost: $5,000.

d. Paragon Dam.

(1) General Observations. The first dam inspected on 28 April was Paragon Dam, which is located in Providence, about two tenths of a mile downstream from where the river turns sharply to the north after passing close to Route 6 (see figure 1). Overall condition of the dam was fair. Paragon Dam is a concrete spillway with outlet works on either end. Mill buildings line both sides of the river. Access to the right (east) side of the dam was through a hole in a chain link fence; access to the left side was obtained only by walking across the spillway crest. Almost all flow was going through the left (west) outlet works whose gate had been removed, and the pool behind the dam was about 2 feet below the spillway crest. Backwater covered the entire toe of the dam. The Paragon Dam appendix contains copies of photographs taken during the April 1999 inspection.

(2) Available Information. Available information on this dam came from a WPA drawing from November 1940 from RIDEM, and survey data in a draft December 31, 1998 Battelle report to the Corps ("Hydrodynamic Modeling Site Survey, Woonasquatucket River, Providence, Rhode Island"). Where dimensions from the Battelle report did not agree with those in the WPA drawings, the more recent Battelle dimensions were used in the hydraulic analyses. The general features and dimensions of the dam observed in the field match those in the drawing and Battelle report, although there were no flashboards or footbridge across the spillway crest. Dimensions from the WPA drawing and Battelle survey are in the hydrology and hydraulics section of the Paragon Dam appendix.

The WPA drawing shows a concrete dam that is almost entirely spillway in a channeled section of the river between two mill buildings. There are outlet works on either end of the 96-foot long spillway. The spillway has an approximate ogee shape. Elevations for the dam appeared to be based on arbitrarily setting the spillway to 50.0 feet, and were not equivalent to NGVD.

The Battelle report does not describe the dam, but gives elevations related to NGVD. It shows a 95.4-foot spillway having a spillway crest elevation varying from 21.6 to 21.8 feet, NGVD. Abutment elevations are given as 25.8 feet.

(3) Abutments. The abutments are in fair to good condition. Brush and grass are growing in the west abutment.

(4) Seepage. Seepage emergence (piping or boils) was not observed at the dam abutments. A backwater prevented observations of seepage at the spillway.

(5) Outlet Works. Water was flowing through each of the gates at the time of inspection. The right gate was fully raised, but debris greatly restricted flow through it. The inlet and outlet channels were clear.

(a) Right Outlet Structure. The right outlet structure was in good condition. The timber gate was in the raised position, but debris in the outlet structure allowed very little flow through the opening. There were numerous hairline cracks with efflorescence on the left wall of the outlet structure, which intersects the spillway.

(b) Left Outlet Structure. The left outlet structure was in good condition. The gate was missing, and water was flowing rapidly through the structure. Severe concrete deterioration was noted at the timber gate guides. This deterioration was reflected through to the right wall of the outlet structure, which intersects the spillway. There was moderate abrasion of the interior concrete walls of the gate structure due to the rapid flow of the water. Downstream of the spillway weir, there was a spall measuring 4 square feet by 1 inch deep and there were numerous cracks with efflorescence at the right wall. Abrasion of the right wall up to the waterline was also noted.

(6) Spillway. The concrete spillway was in fair condition. There was severe and extensive spalling, measuring up to 8 inches deep, on the downstream face for the entire length of the spillway. However, the concrete of the downstream face was generally sound and not further deteriorated. The crest of the spillway was mostly sound, but there were some areas of unsound concrete scattered along the length of the spillway. There was minor to moderate abrasion of the spillway on the upstream face of the spillway up to the waterline. Cracks, up to ¼ inch thick, were noted at the one-third and two-thirds points of the spillway crest. A chair and other debris were caught on the spillway crest or just behind it. Bent pins and remnants of flashboard anchors were visible on the spillway crest.

The river channel was lined with walls upstream and downstream of the dam except upstream of the west abutment. The upstream channel was clear of vegetation, debris, and rocks. One depositional area was observed about 40 feet downstream of the dam in the middle of the river. Trees up to 12 inches in diameter and 40 feet tall were growing in this depositional area.

(7) Spillway Capacity. The spillway at Paragon Dam can pass the 50-year peak discharge, but the dam will be overtopped by over half a foot during the 100-year flood. For events equal to or greater than the 30-year flood, a backwater will submerge the spillway. Even though the dam is overtopped during the 100-year flood, the difference in water surface elevations above and below the dam would not be large, and a sudden catastrophic failure would be unlikely. The drop in water surface elevation across the dam would be 3.2 feet for the 50-year flood and 2.6 feet for the 100-year. Erosion may occur around the abutments during a large flood, but the masonry walls on either side of the dam should contain the sediments behind it. Additional information on the determination of flood frequencies and spillway capacity is in the hydrology and hydraulics section of the Paragon Dam appendix.

(8) Recommendations. To help insure continued adequate performance of

the dam, debris and excess vegetation should be removed and spalled and deteriorated concrete should be repaired immediately. A regular monitoring program should be implemented to check for movement or shifting of the dam.

(a) Outlet Works. Both the right and left outlet structures should be repaired to be operational during emergencies or inspections and repairs of the spillway. Debris should be removed from the right outlet structure and the gate replaced if needed. Deteriorated concrete on the left outlet structure should be repaired and the missing gate replaced. Estimated cost: $15,000.

(b) Spillway. The downstream face of the spillway should be built up to the original design surface with concrete. Areas of deteriorated concrete on the spillway crest should be identified and repaired with a concrete repair mortar. Estimated cost: $12,000.

(c) Debris and Vegetation. Debris, brush and tree growth should be removed from behind the dam, west abutment, and downstream depositional area. Root holes remaining after the removal operation should be filled and repaired with materials that match conditions adjacent to them. Estimated cost: $3,000.

e. Rising Sun Dam.

(1) General Observations. The second and last dam inspected on 28 April was Rising Sun Dam, which is located in Providence, in Lonigan Memorial Park, less than a tenth of a mile from where the river takes a sharp turn to the east (see figure 1). We had good access to both sides of the dam, and found its overall condition was fair to good. The spillway and outlet works are of concrete; wingwalls are of concrete or masonry-faced concrete. Discharge gates are closed and appear to be inoperable. There was spalling and abrasion of the concrete in the outlet works and spillway and excessive vegetative growth on the embankment. The Rising Sun Dam appendix contains copies of photographs taken during the April 1999 inspection.

(2) Available Information. Available information on this dam from RIDEM includes drawings of the dam prepared by the WPA in November 1940, and plans for "River Channel Relocation and Other Work" by Donstan Corp, in December 1955. Survey data on Rising Sun Dam is included in a draft December 31, 1998 Battelle report to the Corps ("Hydrodynamic Modeling Site Survey, Woonasquatucket River, Providence, Rhode Island"). Where dimensions from the Battelle report did not agree with those in the WPA drawings, the more recent Battelle dimensions were used in the hydraulic analyses. Dimensions from the WPA and Battelle are in the hydrology and hydraulics section of the Rising Sun Dam appendix.

The RIDEM drawings show a concrete dam built downstream of and slightly higher than an earlier timber crib dam. The new dam has a concrete spillway, outlet works

on the right end of the spillway, and a water supply intake on the left. The downstream slope of the spillway has about a 1.5 vertical to 1 horizontal slope. The WPA drawing gives the spillway length as 98 feet, but there is a hand-written note saying the original plans gave it as 96 feet, and the Donstan Corp drawing shows the spillway length as 95 feet. Outlet works consist of two 4.5-ft wide by 9-ft high slide gates with a hoisting mechanism. The drawings do not give a description of the water intake. The channel relocation work in the Donstan drawing is to move the river more to the left so that it approaches the dam straight on. Elevations for the dam in the WPA drawing appeared to be based on arbitrarily setting the spillway to 50.0 feet, and were not equivalent to NGVD.

The Battelle report does not describe the dam, but gives elevations related to NGVD. It shows a 97.3-foot spillway having a spillway crest elevation varying from 16.4 to 16.5 feet, NGVD. Elevation of the left abutment wall is given as 22.6 feet, NGVD.

The general features and dimensions of the dam as observed in the field matched those in the drawings, and the river channel approaches the dam straight on as depicted in the Donstan Corp plan.

(3) Abutments. The abutments are in fair to good condition. A moderate amount of runoff and pedestrian erosion was observed immediately downstream of west abutment. Excessive vegetation (brush and trees up to 18 inches in diameter and 40 feet tall) is growing in and around the abutments.

(4) Seepage. Seepage emergence (piping or boils) was not observed at the dam abutments. The existing vegetation at the abutments made it difficult to assess possible seepage problems. Spillway flow prevented observations of seepage at its toe.

(5) Outlet Works. The outlet structure was located at the right (east) side of the spillway and consisted of a concrete gate operator stand (arch portion) with a timber gate and training walls downstream of the gate. The gate structure was in overall poor condition. The two vertical timbers forming part of the lifting mechanism attached to the gate were weathered and cracked. We did not determine if the gate was operable, but it did not appear to be. There was extensive spalling and concrete deterioration of the gate operator stand. Numerous cracks with efflorescence were noted at both the training walls, as well as at the arch portion of the gate structure. The gate was closed with some leakage. The outlet channel was clear, but the inlet channel was inundated and partially clogged with debris.

(6) Spillway. Overall condition of the spillway was good. There was minor to moderate abrasion of the crest of the spillway. Flowing water prevented observations of the exact condition of its downstream face. There was some debris (branches) on the spillway's right side. The left abutment wall of the spillway was constructed of concrete and stones. There were no signs of movement of these stones. There were numerous areas of unsound concrete on the top surface of the left wall.

Channel walls line long reaches upstream and downstream of the dam. There was a visible increase in turbulence in the water surface about 20 feet upstream of the spillway at the location of the old timber crib dam, which was submerged under about a foot of water. An island has formed on the right-hand side of the spillway approach channel from debris caught on the remains of the upstream timber crib dam; a willow tree with a trunk diameter of 8 or more inches has grown on this island. Another depositional area was observed downstream along the east abutment. Some debris and a few large stones were noted in the channel downstream of the dam.

(7) Spillway Capacity. In the absence of a significant backwater, the Rising Sun Dam's spillway capacity is 2,600 cfs, about equal to the 50-year flood. However, a backwater begins to submerge the spillway during the 15-year flood, and the dam would be overtopped by 0.7 feet during the 50-year flood. During the 100-year flood, overtopping would be 1.1 feet. Despite this overtopping, the difference in water surface elevations above and below the dam during this event would not be large—about 2.2 feet during the 100-year flood, and the dam would be unlikely to suffer a sudden catastrophic failure. The 1.1-feet of overtopping would be on the right abutment (looking downstream), but this area is paved and unlikely to suffer severe erosion. Overtopping of the left embankment would be less—about 0.8 feet. Although this area of exposed earth would experience more erosion than the right embankment, masonry walls would likely prevent failure of the embankment and the washout of sediments from behind the dam. Restoring the capacity of the outlet works could reduce the overtopping of the dam by half a foot. Additional information on the determination of flood frequencies and spillway capacity is in the hydrology and hydraulics section of the Rising Sun Dam appendix.

(8) Recommendations. To help insure continued adequate performance of the dam, debris and excess vegetation should be removed and spalled and deteriorated concrete repaired. The outlet works should be repaired or replaced to allow the pool behind the dam to be lowered for inspection, repairs, or an emergency, and to reduce overtopping during a large flood. A regular monitoring program should be implemented to check for movement or shifting of the dam.

(a) Vegetation. Brush and tree growth, including the root systems, should be removed from the abutments and depositional areas. A sufficient clearance (greater than ten feet) should be provided along the abutments for access and to observe possible seepage. Root holes remaining after the removal operation should be filled and repaired with materials that match the conditions adjacent to them. Estimated cost: $18,000.

(b) Outlet Works. Spalls and areas of concrete deterioration should be identified and repaired at the gate structure. All cracks with efflorescence should be cleaned and repaired. The two weathered and cracked timbers should be replaced, along with any other deteriorated pieces of timber that make up the gate. The gate operator should be repaired or replaced for use during emergencies or inspections and repairs of the

spillway, and reduce overtopping during large floods. Estimated cost: $25,000

f. Stillwater Reservoir.

(1) General. An emergency inspection of Stillwater Reservoir dam by the Corps in February 1998 found it to be in poor condition. Rhode Island has hired an engineering firm to evaluate the dam, and recommend and design improvements, but also asked the Corps to evaluate the spillway capacity relative to flood frequencies in the watershed. The Corps did not inspect this project for structural integrity in April 1999, but was familiar with it from the 1998 inspection.

Stillwater Reservoir is located on the Woonasquatucket River in the town of Smithfield, Rhode Island (see figure 3), and has a drainage area of 24.1 square miles at the dam's outlet. Cahn Engineers, Inc. completed a Phase I inspection of the dam in 1981 for the Corps, and classified it as a high hazard, intermediate size project. Based on Corps guidelines, such a project should be able to pass the full PMF without overtopping the dam. Using rule-of-thumb procedures, the Cahn report estimated the full PMF discharge at 15,700 cfs and concluded it would overtop the dam by 2.3 feet.

(2) Spillway Capacity. Peak discharge frequencies were determined from analysis of the USGS gaged records and adjusted to Stillwater Reservoir by drainage area ratios. Results were compared with elevations and peak flows presented in the Smithfield Flood Insurance Study (FIS). The FIS results were considered reasonable and adopted for use in this assessment. Peak outflows from Stillwater Reservoir for various frequencies as determined from the FIS are shown in figure 2. Discharge ratings were computed for the spillway at Stillwater Reservoir using the standard weir equation with a coefficient of 2.7. This relatively low weir coefficient was adopted in the Phase I inspection and is considered representative of this project that has a broad crested weir in poor condition. Based on this discharge rating curve, the spillway is capable of passing the estimated 100-year discharge of 1,680 cfs with about 0.4 feet of freeboard, assuming the top of the dam is at elevation 211 feet, NGVD, as presented in the Phase I report.

(3) Surcharge Storage. The Corps evaluated effects of surcharge storage to determine if there would be enough to significantly reduce previously developed estimates of peak discharges. Since computation of detailed inflow hydrographs was beyond the scope of this effort, a more cursory evaluation was performed. Stillwater Reservoir has surface areas of 240 acres at spillway crest elevation 207 feet, and 380 acres at top of dam elevation of 211 feet, NGVD. Simple geometry gives a total of 1240 acre-feet of surcharge storage between the spillway crest and top of dam, equivalent to about an inch of runoff from the upstream watershed. At the computed 100-year flood elevation of 210.6 feet there would be about 0.9 inches of surcharge storage. While these are not insignificant volumes, they are not enough to have significant impacts on peak outflows from large flood events such as the 100-year or greater. Consequently, the estimated 100-year discharge of 1,680 and PMF discharge of 15,700 cfs should not be changed significantly

Location of Stillwater Reservoir Dam

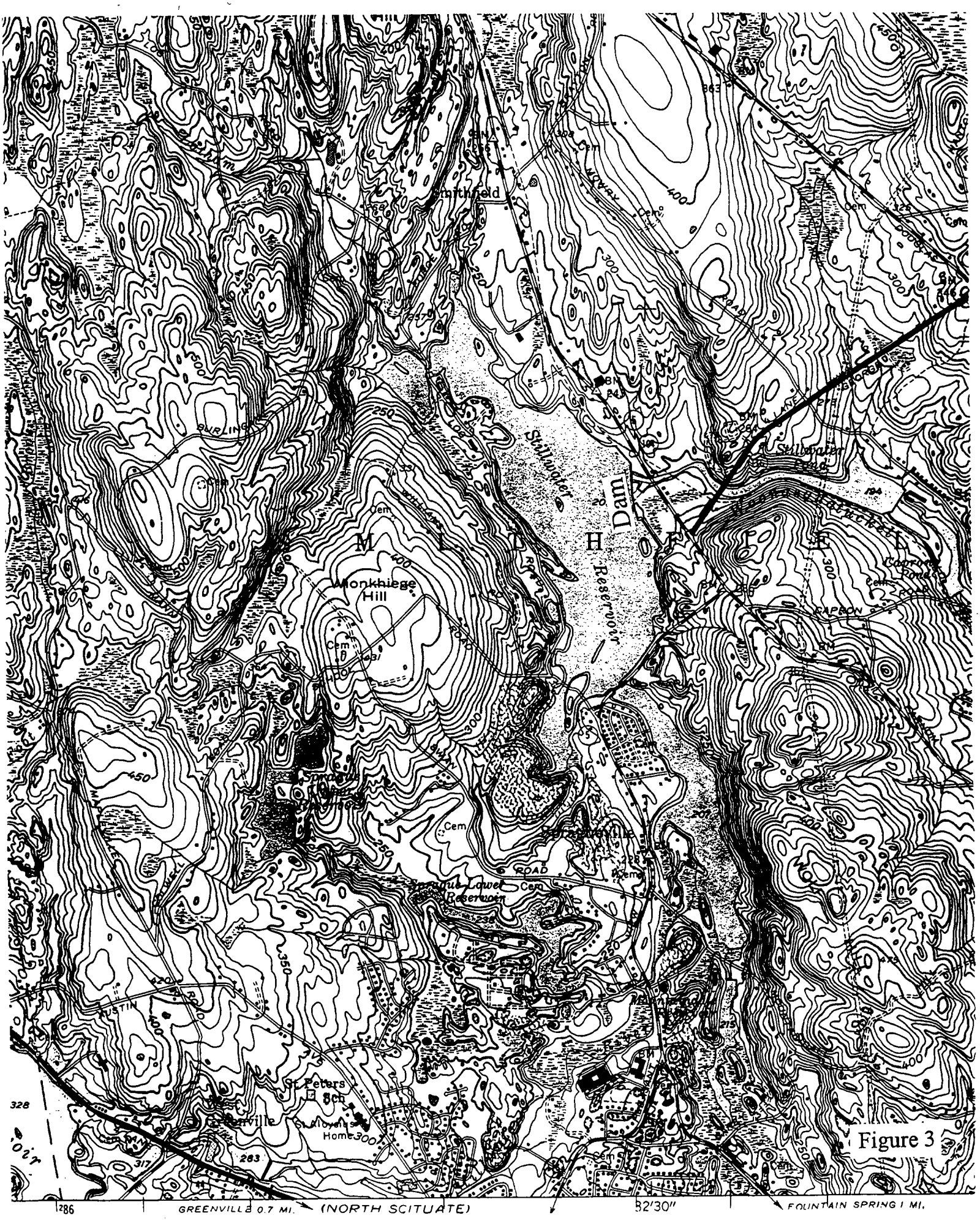

Figure 3

because of surcharge storage effects.

(4) Conclusions. Corps guidelines call for high hazard, intermediate size dams to be able to pass the PMF without being overtopped. The Phase I report's PMF discharge of 15,700 cfs is still valid, based on the rule-of-thumb guidelines used to develop it. Further analysis of the dam and spillway should include a more detailed development of the PMF and consider the effects of backwaters on spillway capacity and at risk areas downstream.

WOONASQUATUCKET RIVER DAM INVESTIGATIONS
RHODE ISLAND

APPENDIX A

LYMANSVILLE DAM

INSPECTION CHECKLISTS
PHOTOGRAPHS
AND
HYDROLOGY AND HYDRAULICS ANALYSIS

APPENDIX A - LYMANSVILLE DAM

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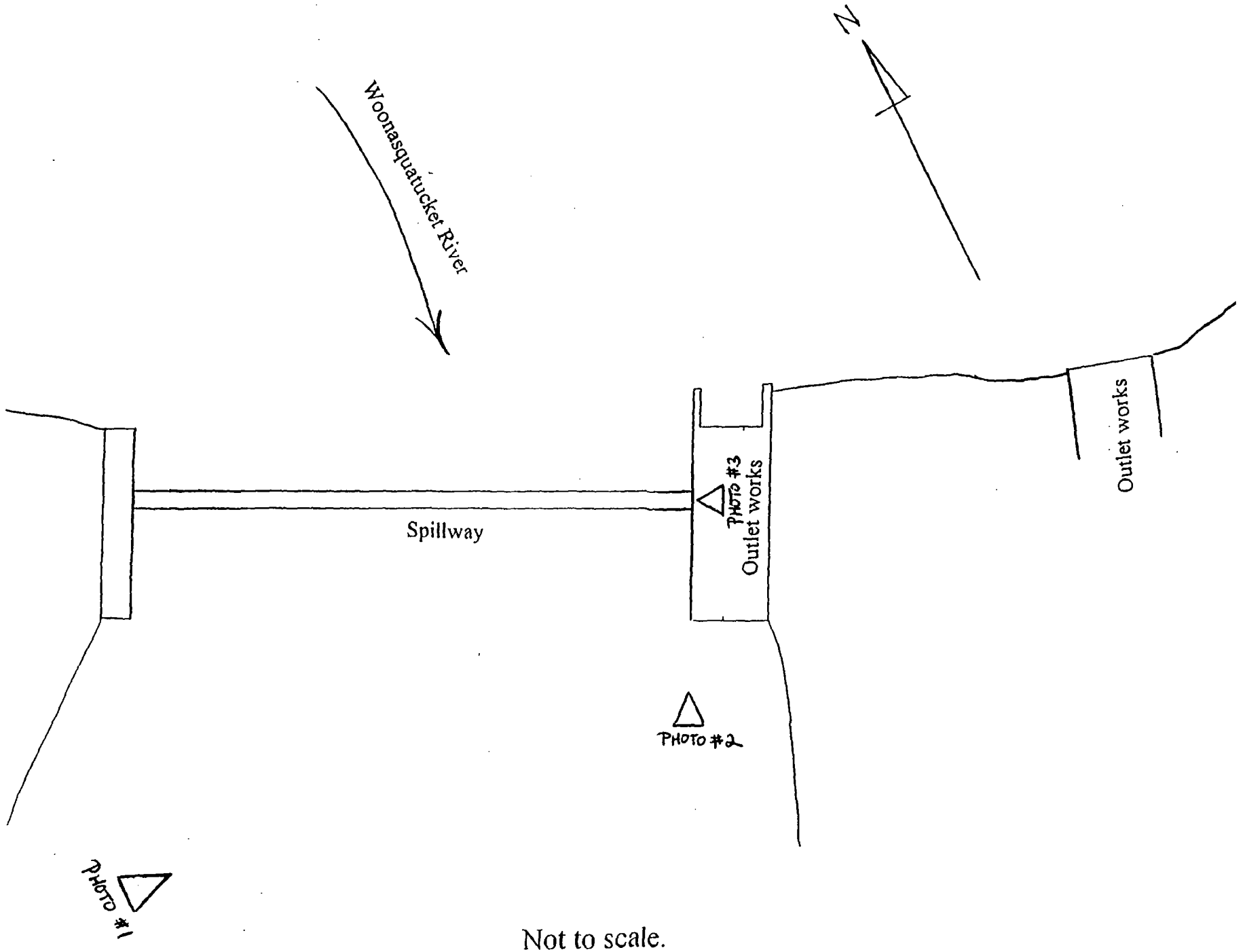
Woonasquatucket River Dams
Inspected in April 1999

TEAM MEMBER CHECKLIST FOR INSPECTION		
AREA EVALUATED	**BY**	**CONDITION**
CONCRETE/STRUCTURAL	**JL**	
GATE STRUCTURE #1		Structure in poor condition. Appeared to be inoperable, covered with debris, and deteriorated.
GATE STRUCTURE #2		Gates are not operable. Stones are well bonded and aligned. Minor vegetation growing in the joints. Debris inside both openings of the structure.
GATE STRUCTURE #3		Not found, therefore, was not inspected.
SPILLWAY		
a. Spillway		
General Condition		Good, with minor to moderate surface abrasion at the crest.
Debris		A section of tree trunk caught on the top left side, otherwise, it was free of obstructions to flow.
b. Concrete Apron		
General Condition		Not possible to observe due to the rapid flow of water down the spillway.
Large Flagstones		No signs of past significant movement, and are in good condition.
	JL	

TEAM MEMBER CHECKLIST FOR INSPECTION		
AREA EVALUATED	**BY**	**CONDITION**
CONCRETE/STRUCTURAL	**JL**	
SPILLWAY, CONT'D		
c. East Abutment Wall		
General Condition		Good, with minor to moderate abrasion at the intersection with the spillway, both at the crest and on the downstream face.
Spalls		7' long x 1'-6" wide x 9" deep spall at the corner of the wall.
Condition of Joints		Good alignment of joints; no signs of movement of stones.
d. West Abutment Wall		
General Condition		Good, with minor to moderate abrasion at locations similar to the east abutment wall.
Deteriorations		Minor deterioration at the top surface of the wall.
Condition of Joints		Good alignment of joints; no signs of movement of stones.
	JL	

Lymansville Dam – Photo Locations



Not to scale.

Photo 3: West abutment wall and the spillway crest. *Note: the rapid flow of water over the spillway and the graffiti on the west abutment wall.*

LYMANSVILLE DAM INSPECTION

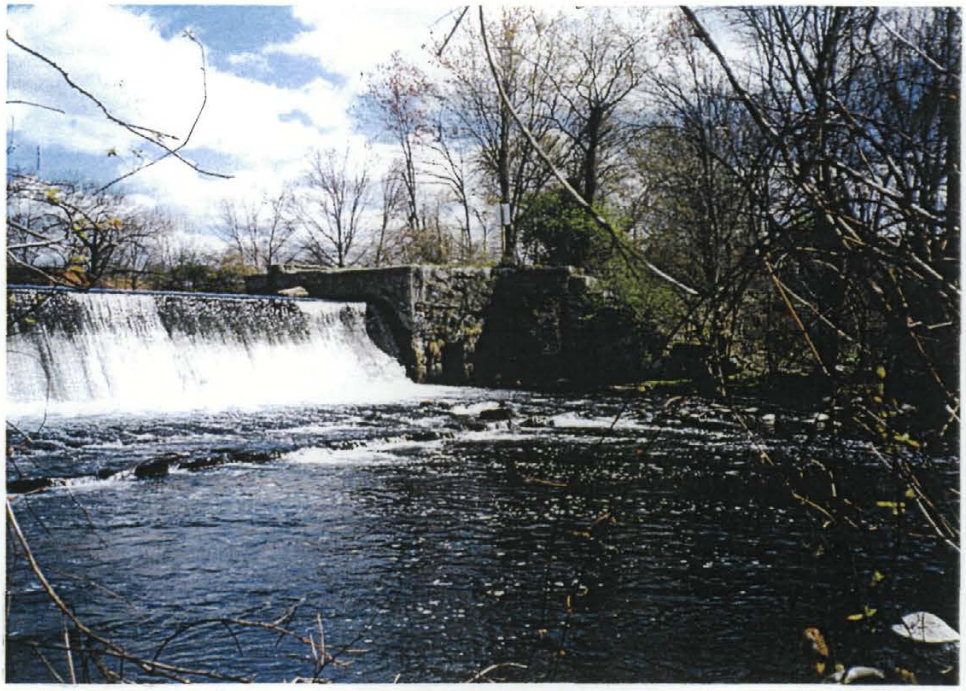


Photo 1: Gate structure #2, located at the left side of the spillway. *Note: the section of tree trunk caught at the spillway crest.*

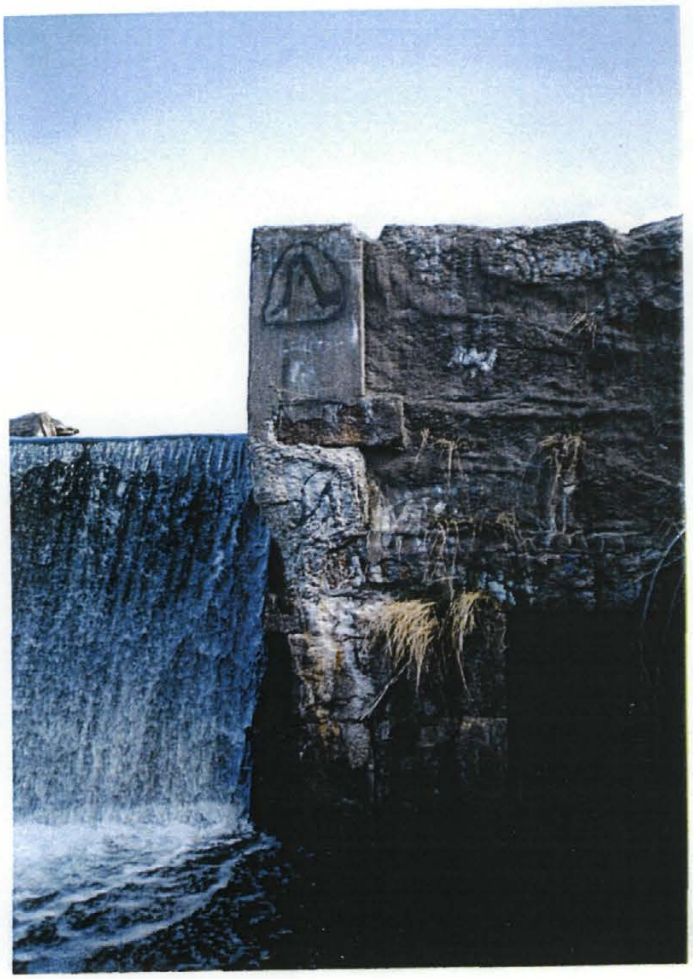


Photo 2: 7′ long x 1′-6″ wide x 9″ deep spall at the corner of the east abutment of the spillway. *Note: the vegetation growing at the joints of gate structure #2.*

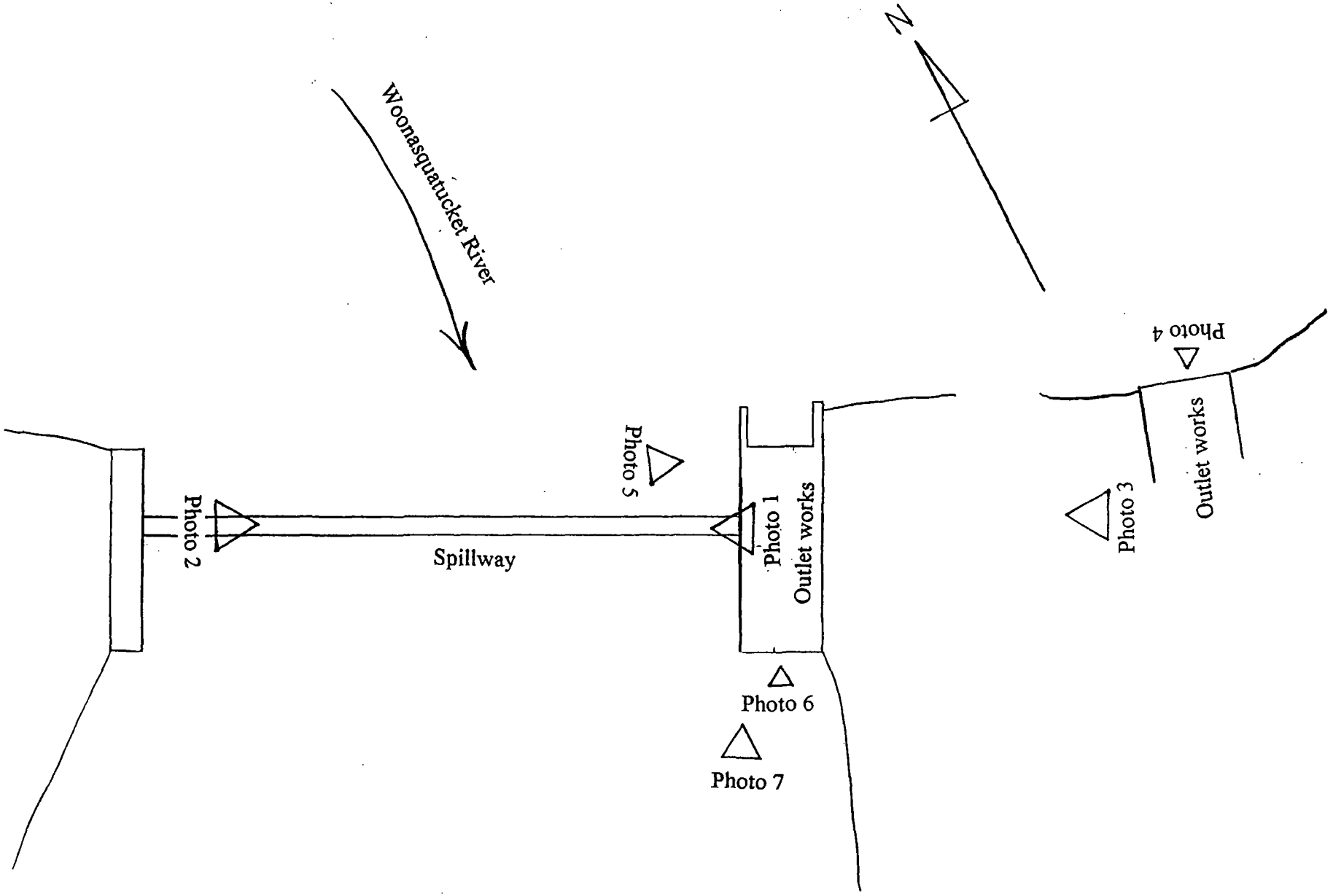
TEAM MEMBERS CHECK LISTS FOR INSPECTION NO. 1		
AREA EVALUATED	BY	CONDITION
GEOTECHNICAL		
EARTH EMBANKMENT		
Crest Elevation	PS	Elevation 53.5 to 54.5 feet
Surface Cracks		None observed.
Movement or Settlement of Crest		None observed.
Lateral Movement		None observed.
Vertical Alignment		Fair. Very irregular.
Horizontal Alignment		Fair. Very irregular.
Indications of Movement of Structural Items on Slope		None observed.
Trespassing on Slopes		Trespass paths throughout.
Sloughing or Erosion of Slopes		Erosion from runoff throughout.
Stone Slope Protection		None.
Unusual Movement or Cracking at or Near Toes		None observed.
Unusual Embankment or Downstream Seepage		None observed.
Piping or Boils		None observed.
Foundation Drainage Features		None at project.
Toe Drains		None at project.
Instrumentation	PS	None at project.

TEAM MEMBERS CHECK LISTS FOR INSPECTION NO. 1		
AREA EVALUATED	BY	CONDITION
GEOTECHNICAL		
EARTH EMBANKMENT (Con't)		
Vegetation and/or Debris	PS	Major. Vegetation needs to be removed from toes, slopes and crests.
ABUTMENTS		
Condition at Concrete Structures		Fair to good. Eroded depression noted at west end of spillway.
Condition at river banks		Good.
OUTLET WORKS		
Gate #1		
Intake Channel		Blocked with debris and vegetation.
Outlet Channel		Covered with soil.
Gate		Closed and inoperable.
Gate #2		
Intake Channel		Submerged.
Outlet Channel		Clear.
Gate		Closed and inoperable. Approximately 100 gpm of water flowing through base.
Gate #3		No longer exists or has been filled.
Spillway		
Intake Channel		Submerged. Deposition within 2 feet of spillway crest.
Outlet Channel		Clear.
Weir	PS	Seepage flows through cracks and holes in weir.

Team Members Check Lists for Inspection of **Manton Dam**		
Area Evaluated	By	Conditions
Hydrology/Hydraulics		
Spillway	TB	Concrete.
Approach Channel		Clear of obstructions
Condition		Fair to good – some spalling of concrete. Very little debris on spillway crest.
Stilling Basin		None. Discharges to a concrete apron – flow prevented direct observation.
Discharge Channel		Generally clear – free of major obstructions.
Outlet Works		On left side of spillway.
Inlet		
Channel		Generally clear – some debris.
Trash Rack		None.
Emergency Closure		Inoperable.
Gates		Wooden – inoperable.
Gate Passage		NA
Outlet		Buried under boulders and earth.
Stilling Basin		NA
Exit Channel		Buried under boulders and earth.
Instrumentation		None.
Rain Gage		None.
Pool Stage Recorder		None.
Log Boom		None.

Team Members Check Lists for Inspection of **Lymansville Dam**		
Area Evaluated	By	Conditions
Hydrology/Hydraulics		
Spillway	TB	Granite block.
Approach Channel		Clear of obstructions.
Condition		Fair to good condition – some spalling of concrete. Very little debris on spillway crest.
Stilling Basin		None. Spillway discharges to a concrete apron in fair to good condition.
Discharge Channel		Clear of obstructions.
Outlet Works (1)		On left side of dam.
Inlet		
Channel		Generally clear – some debris.
Trash Rack		None.
Emergency Closure		Inoperable.
Gates		Wooden – inoperable.
Gate Passage		NA
Outlet		Buried under earth fill.
Stilling Basin		NA
Exit Channel		Buried under earth fill.
Outlet Works (2)		On left side of spillway.
Inlet		
Channel		Clear.
Trash Rack		None.
Emergency Closure		Inoperable.
Gates		Wooden – inoperable.
Gate Passage		NA
Air Vent		NA
Outlet		Two – 4' by 4'
Stilling Basin		None.
Exit Channel		Channel clear of obstructions. Discharges to spillway apron.
Instrumentation		None.
Rain Gage		None.
Pool Stage Recorder		None.
Log Boom		None.

Lymansville Dam – Photo Locations



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Lymansville Dam – 27 April 1999

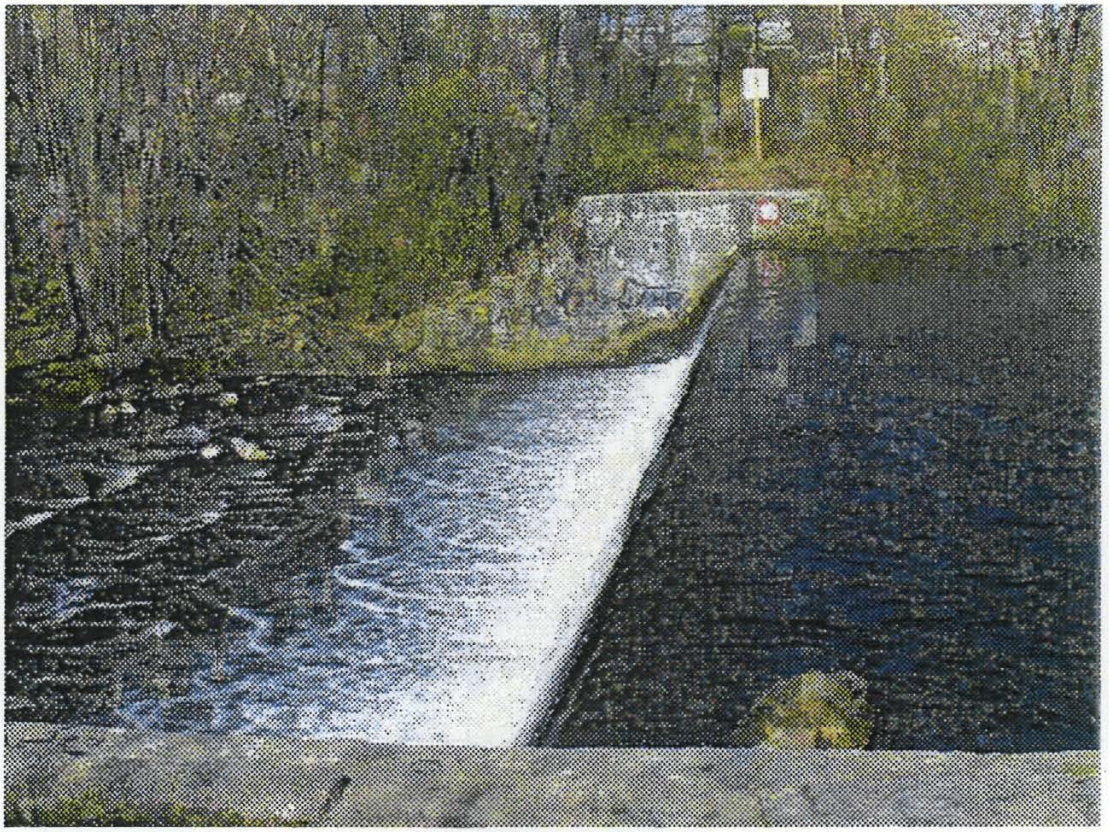

Photo 1 – Overview of spillway from left wing wall.

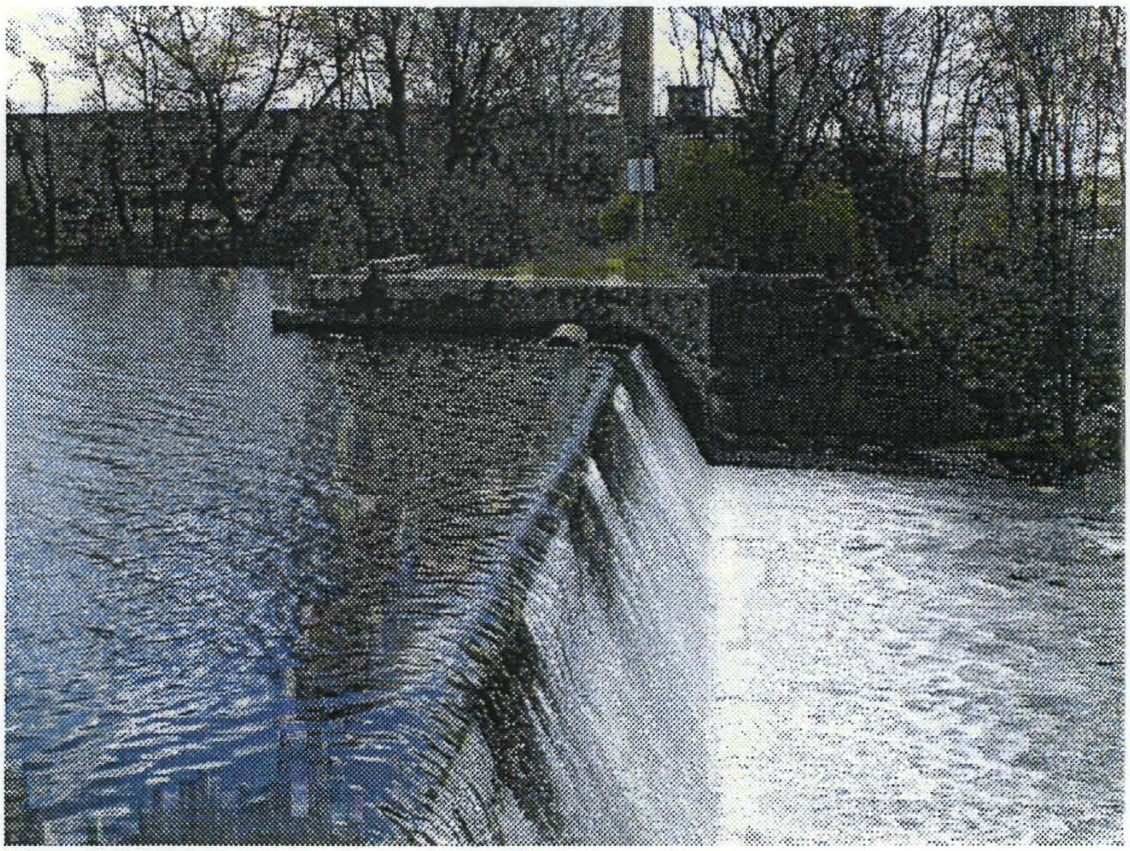

Photo 2 – Overview of spillway from right wing wall.

Photo 3 – Dam crest on left embankment showing heavy tree and brush growth.

Photo 4 – Outlet works on left bank.

Photo 5 – View of outlet works on left end of spillway.

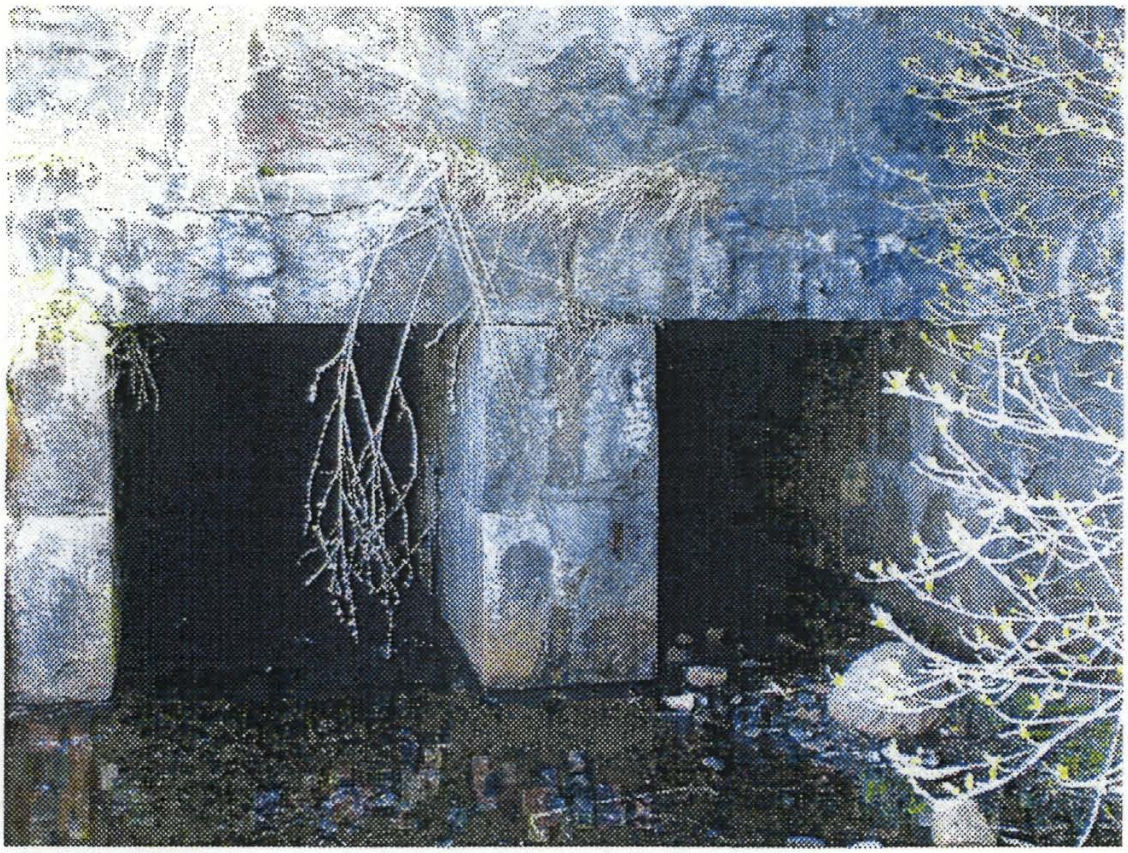

Photo 6 – Downstream end of outlet works on left side of spillway.

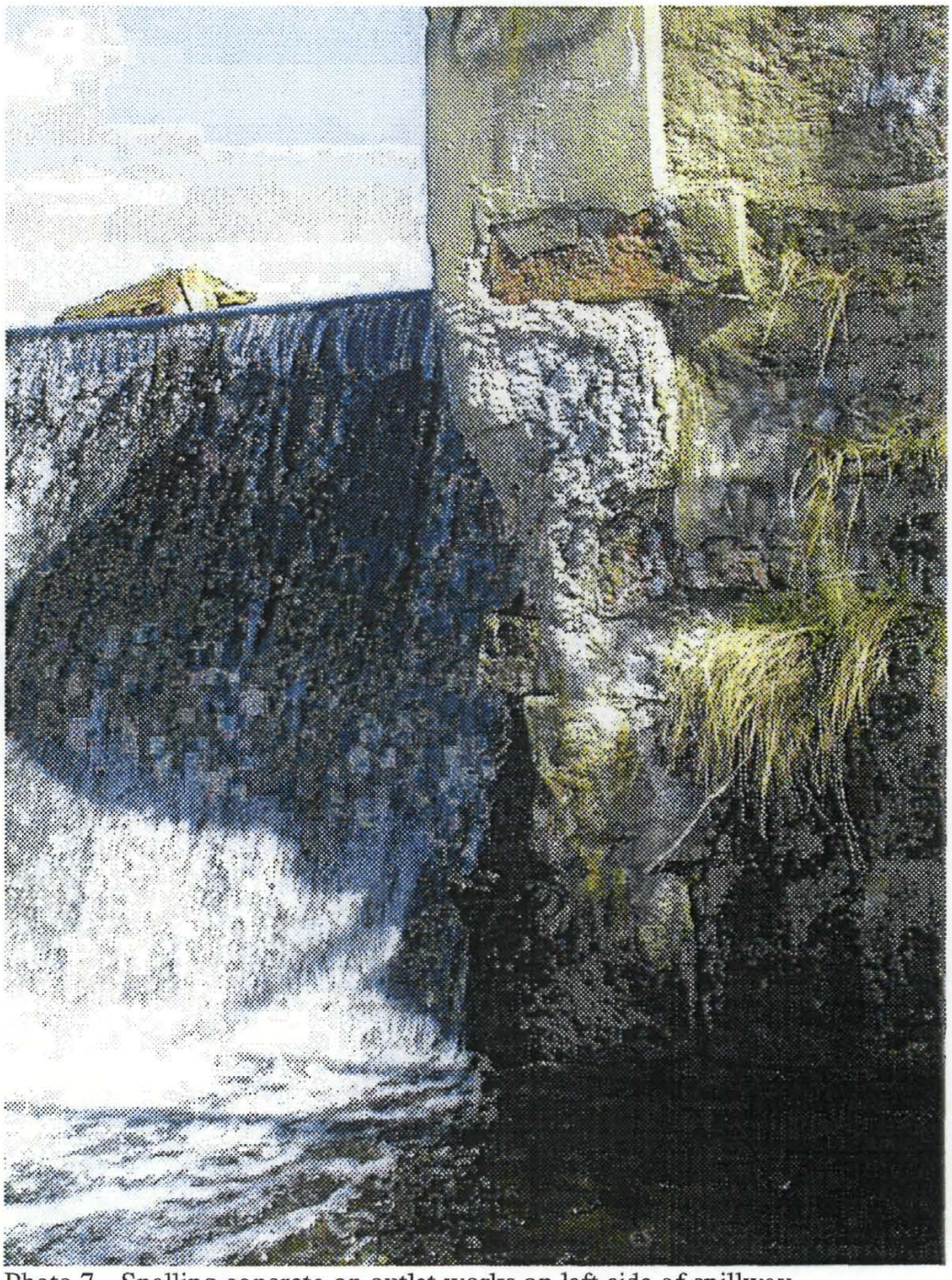

Photo 7 - Spalling concrete on outlet works on left side of spillway.

LYMANSVILLE DAM
HYDROLOGY AND HYDRAULICS ANALYSIS

1. Summary. The Lymansville Dam spillway has a capacity of about 3,000 cfs, and can pass the 100-year discharge with about 0.4 feet of freeboard. A backwater reaches part way up the base of the dam during the 100-year discharge, but does not reach the spillway crest. As a result of this backwater, total head difference across the dam is less during the 100-year flow than it is during normal flow conditions, and sudden catastrophic failure of the dam during the 100-year flood is unlikely. However, there are portions of the embankment crests that are eroded and may be two feet or more below the elevation of the abutment walls. During the 100-year flood, water flowing over these unprotected sections could lead to rapid erosion of the embankment followed by possible washout of sediments behind the dam.

2. Dimensions. Available information on this dam came from RIDEM and includes plans prepared by O. Perry Sarle for the Tucker Construction Co. in August 1936, and drawings of the dam prepared by the WPA in November 1940. Plans show the dam as having the following dimensions. Datum for these elevations appears to be based on arbitrarily setting the spillway to 50.0 feet, and does not appear to be related to NGVD.

Elevation of top of dam – 54 ft.
Elevation of spillway crest – 50.0 ft.
Spillway width – 105 ft.
Elevation of spillway toe – 41.61 ft.
Elevation of left wingwall – 54.82 ft.
Elevation of right wingwall – 53.92 ft.
Height of dam – 12-13 ft.
Outlet conduits – 4-ft by 4-ft.

3. Flows. Estimated 100-year peak flood discharges and water levels at Lymansville Dam were taken from the North Providence Flood Insurance Study (NPFIS) and are given in table 1. Estimated 10 and 50-year flows were estimated from the Providence FIS (PFIS) and are also in table 1. The NPFIS did not include profiles for the 10 and 50-year flows at Lymansville Dam.

4. Elevations. Spillway crest elevation of 79.4 feet, NGVD was estimated from a flood profile in the NPFIS. Height of the dam above spillway crest was taken from WPA drawings. The top of dam elevation of 83.4 feet was estimated by adding the 4-foot height above spillway crest to the crest elevation.

Table 1 Peak Discharges and Water Surface Elevations At Lymansville Dam Approximate Spillway Crest Elevation = 79.4 ft, NGVD Approximate Top of Dam Elevation = 83.4 ft, NGVD				
Event (Year)	Flow (cfs)	NPFIS Water Surface Elev. Upstream of Dam (ft-NGVD)	Corps Estimated Water Surface Elev. Upstream of Dam (ft-NGVD)	NPFIS Water Surface Elev. Downstream of Dam (ft-NGVD)
10	1,350			
50	2,170			
100	2,600	80.6	83.0	74.0

5. Spillway Capacity. Spillway capacity was estimated using the standard weir equation. For a condition with a gentle approach slope and a more sharply down-sloping face, a weir coefficient of 3.6 was selected. With a width of 105 feet, height of 4 feet, and weir coefficient of 3.6, the capacity of the spillway is 3,000 cfs. This is greater than the 100-year peak discharge of 2,600 cfs, which would be 3.6-feet deep over the spillway. Although the abutments would not be overtopped, some sections of the earth embankment crest are eroded 2 feet and would be overtopped.

6. Comparisons. The NPFIS shows the 100-year water surface above the dam as about elevation 80.6 feet, NGVD, while calculations as part of this investigation put it at 83.0 feet. Also, the weir elevation of 79.4 feet in the NPFIS does not agree with the USGS Providence, RI quad sheet (revised 1975) that shows the pool level as 76 feet. While these discrepancies are noted, they do not affect conclusions about whether the spillway can pass the 100-year flow or the risk of sudden catastrophic failure of the dam.

WOONASQUATUCKET RIVER DAM INVESTIGATIONS
RHODE ISLAND

APPENDIX B

MANTON DAM

INSPECTION CHECKLISTS
PHOTOGRAPHS
AND
HYDROLOGY AND HYDRAULICS ANALYSIS

APPENDIX B – MANTON DAM

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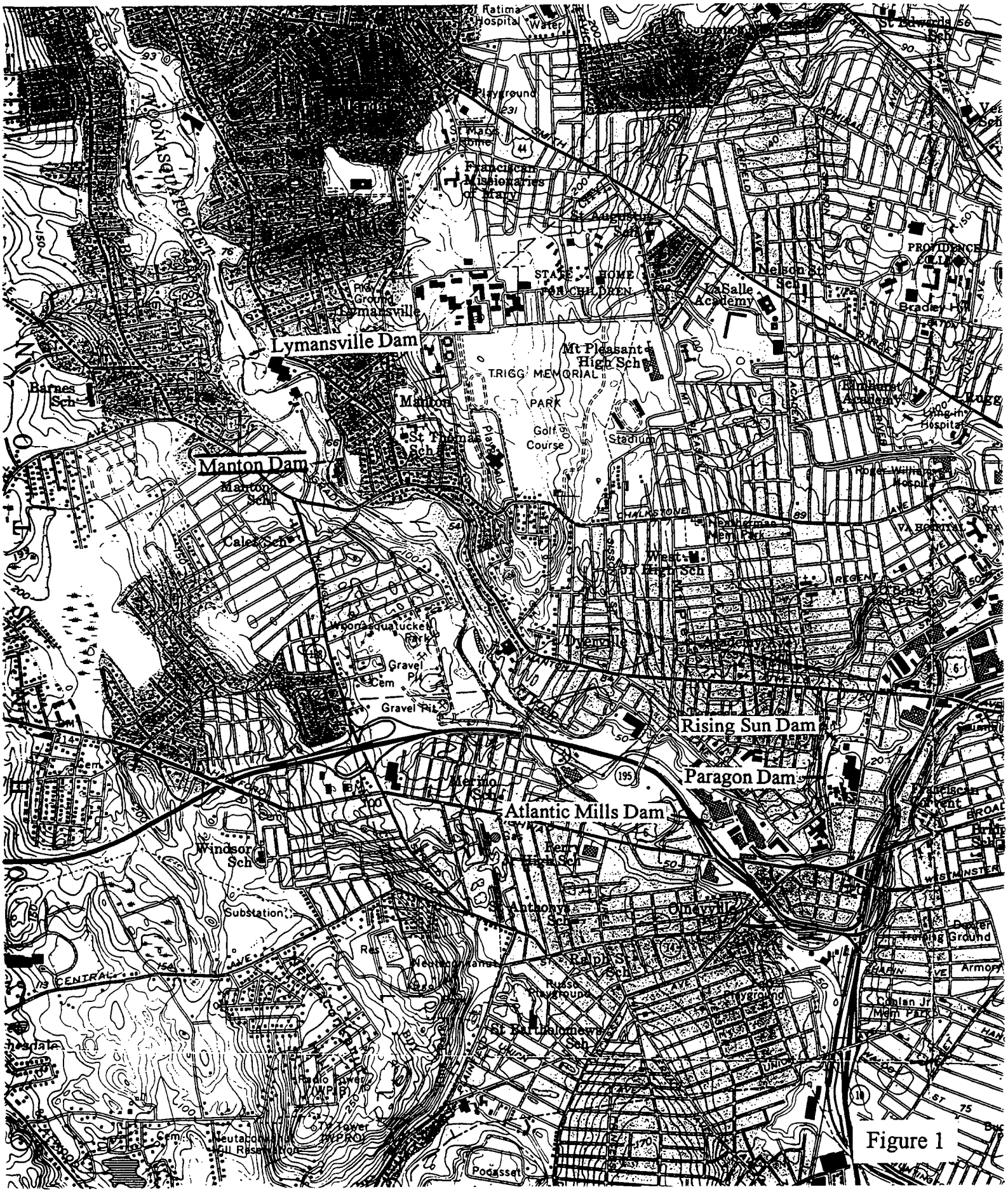
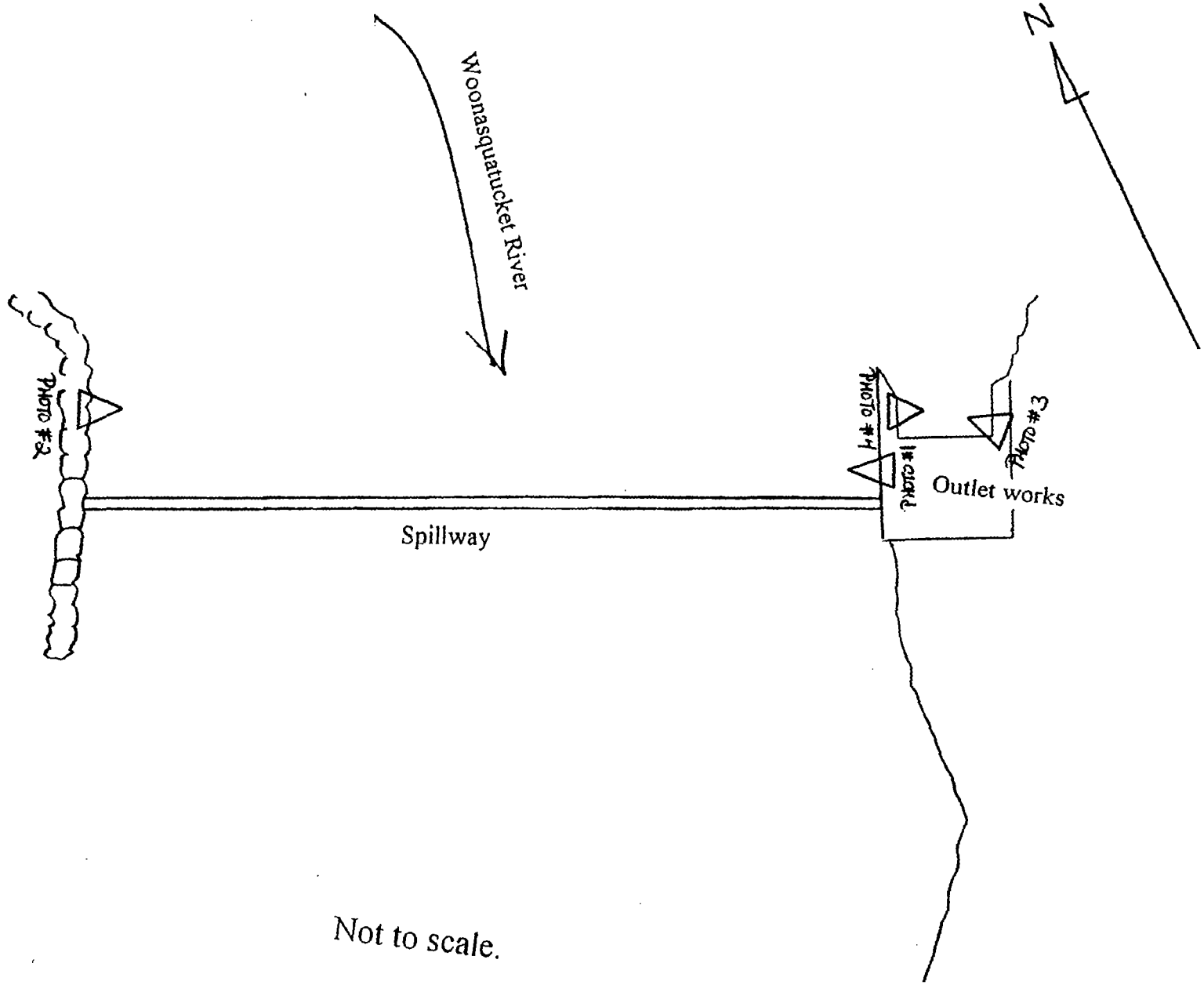
Woonasquatucket River Dams
Inspected in April 1999



TEAM MEMBER CHECKLIST FOR INSPECTION		
AREA EVALUATED	**BY**	**CONDITION**
CONCRETE/STRUCTURAL	**JL**	
SPILLWAY		
a. Spillway		
General Condition		Good, with minor to moderate surface abrasion and deterioration of the crest.
Debris		Some tree branches were caught at the 12x12 timber beam of the old spillway wall
b. Concrete Apron		
General Condition		Not possible to observe due to the rapid flow of water down the spillway.
Heavy Riprap		Submerged
c. West Abutment Wall		
General Condition		Good, with minor abrasion at the intersection with the spillway, both at the crest and on the downstream face.
Spalls		Concrete facing over the existing stone wall has spalled off on the inside face of the wall for @ 10′, exposing the inner stone core. Also missing for the full width of the wall and @ 4′ long on the top surface of the wall.
	JL	

TEAM MEMBER CHECKLIST FOR INSPECTION		
AREA EVALUATED	**BY**	**CONDITION**
CONCRETE/STRUCTURAL	**JL**	
SPILLWAY, CONT'D		
Condition of Joints		No deterioration or vegetative growth noted at the joints of stone wall.
d. East Abutment Wall		
General Condition		Fair to good. Areas of deterioration noted.
Spalls		Spall with exposed rebar, measuring 6' long x 3' high x 1'-4" deep at the upstream/leading end of the wall. The concrete around is unsound and severely abraded.
GATE STRUCTURE		
General Condition		Poor and not operational. Gates have been removed and the brackets that were behind are corroded.
Spalls		Numerous areas of concrete deterioration around the gate stem opening. An area of deterioration, up to 3" deep, is located at the bottom of the east training wall. A spall, measuring 6' long x 4' wide x 1" deep, located at the top of the slab.
Debris	**JL**	Outlet blocked with boulders.

Manton Dam – Photo Locations



Not to scale.

Photo 1: Concrete facing of the stone core wall has spalled off at the west abutment wall. *Note: the debris caught at the 12x12 timber beam of the old spillway wall.*

Photo 2: East abutment wall. *Note: the spall with exposed rebar at the upstream/leading end of the wall.*

Photo 3: 6′ long x 3′ high x 1′-4″ deep spall with exposed rebar at the east abutment wall. *Note: the deteriorated concrete around the gate stem opening of the gate structure.*

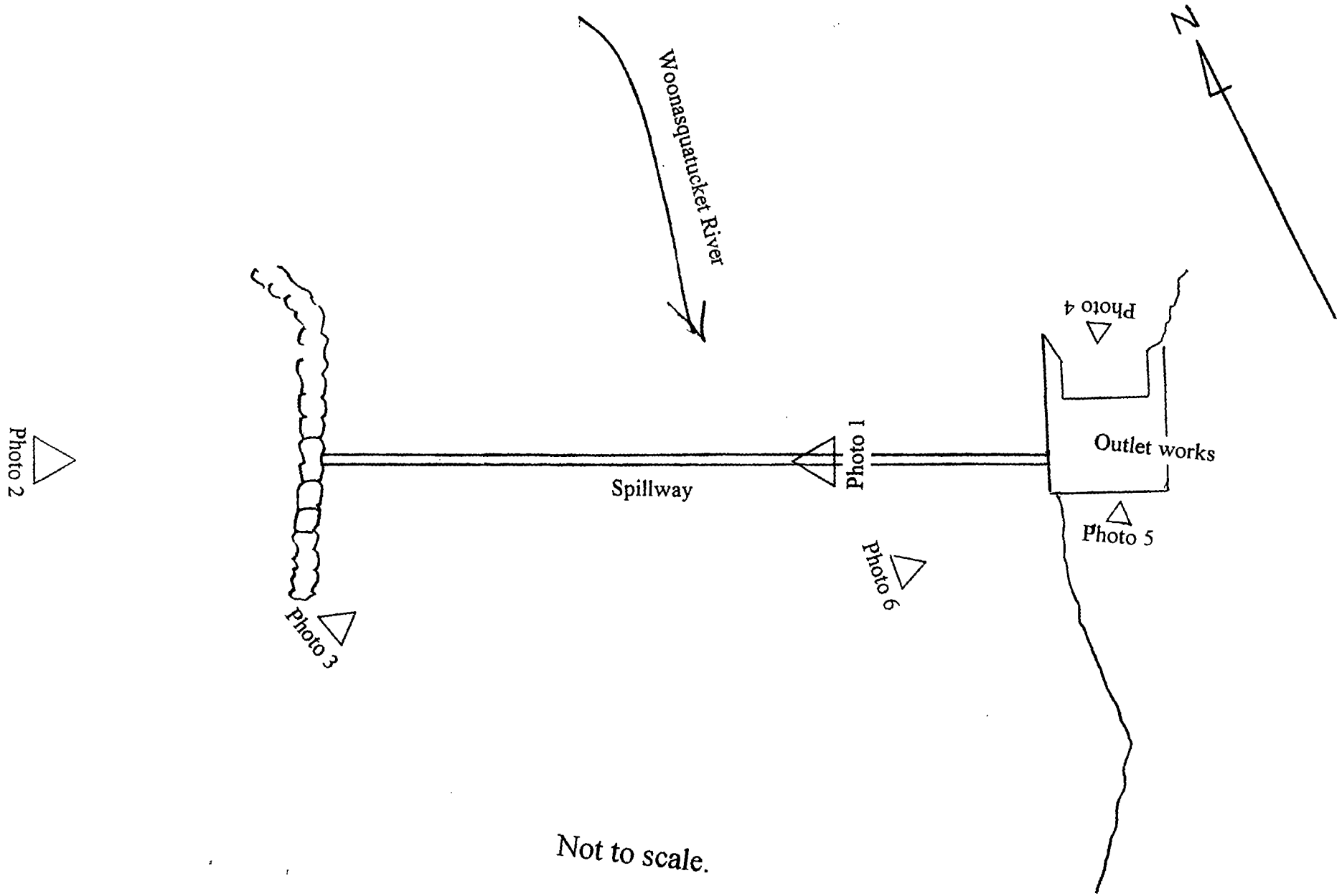
Photo 4: Two full height cracks, measuring up to 1/2″ thick x 1′-4″ deep at the east training wall of the gate structure. *Note: the deteriorated concrete, up to 3″ deep, at the bottom of one of the cracks.*

TEAM MEMBERS CHECK LISTS FOR INSPECTION NO. 1		
AREA EVALUATED	BY	CONDITION
GEOTECHNICAL		
EARTH EMBANKMENT		
Crest Elevation	PS	Elevation 51.2 to 55.2 feet
Surface Cracks		None observed.
Movement or Settlement of Crest		None observed.
Lateral Movement		None observed.
Vertical Alignment		Fair. Very irregular.
Horizontal Alignment		Fair. Very irregular.
Indications of Movement of Structural Items on Slope		None observed.
Trespassing on Slopes		Trespass paths throughout.
Sloughing or Erosion of Slopes		Erosión from runoff throughout.
Stone Slope Protection		None.
Unusual Movement or Cracking at or Near Toes		None observed.
Unusual Embankment or Downstream Seepage		None observed.
Piping or Boils		None observed.
Foundation Drainage Features		None at project.
Toe Drains		None at project.
Instrumentation	PS	None at project.

TEAM MEMBERS CHECK LISTS FOR INSPECTION NO. 1		
AREA EVALUATED	BY	CONDITION
GEOTECHNICAL		
EARTH EMBANKMENT (Con't)		
Vegetation and/or Debris	PS	Major. Vegetation needs to be removed from toes, slopes and crests.
ABUTMENTS		
Condition at Concrete Structures		Good. No significant erosion.
Condition at river banks		Fair to Good. Erosion downstream of left abutment.
OUTLET WORKS		
West Gate		
Intake Channel		Submerged.
Outlet Channel		Filled with soil and stone.
Gate		Closed and inoperable.
East Gate		No longer exists or has been filled.
Spillway		
Intake Channel		Submerged. Deposition almost up to spillway crest.
Outlet Channel		Clear.
Weir	PS	Seepage flows through cracks and holes in weir.

Team Members Check Lists for Inspection of **Manton Dam**		
Area Evaluated	By	Conditions
Hydrology/Hydraulics		
Spillway	TB	Concrete.
Approach Channel		Clear of obstructions
Condition		Fair to good – some spalling of concrete. Very little debris on spillway crest.
Stilling Basin		None. Discharges to a concrete apron – flow prevented direct observation.
Discharge Channel		Generally clear – free of major obstructions.
Outlet Works		On left side of spillway.
Inlet		
Channel		Generally clear – some debris.
Trash Rack		None.
Emergency Closure		Inoperable.
Gates		Wooden – inoperable.
Gate Passage		NA
Outlet		Buried under boulders and earth.
Stilling Basin		NA
Exit Channel		Buried under boulders and earth.
Instrumentation		None.
Rain Gage		None.
Pool Stage Recorder		None.
Log Boom		None.

Manton Dam – Photo Locations



Not to scale.

Photo 1 – Overview of right embankment from left.

Photo 2 – Overview of right embankment looking towards spillway.

Photo 3 – Spillway from base of right embankment

Photo 4 – Inlet to outlet works at left end of spillway.

Photo 5 – Soil filling downstream side of outlet works.

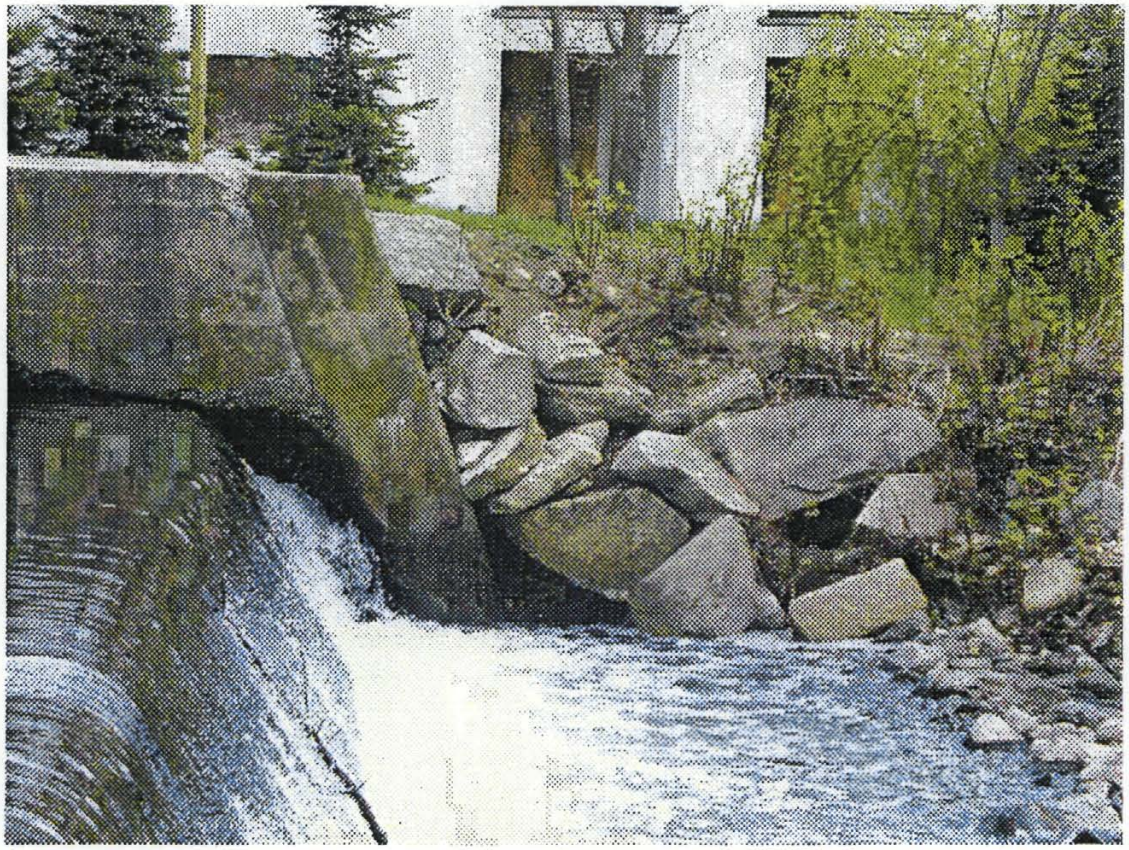


Photo 6 – Boulders and soil blocking outlet works outlet.

Manton Dam – 27 April 1999

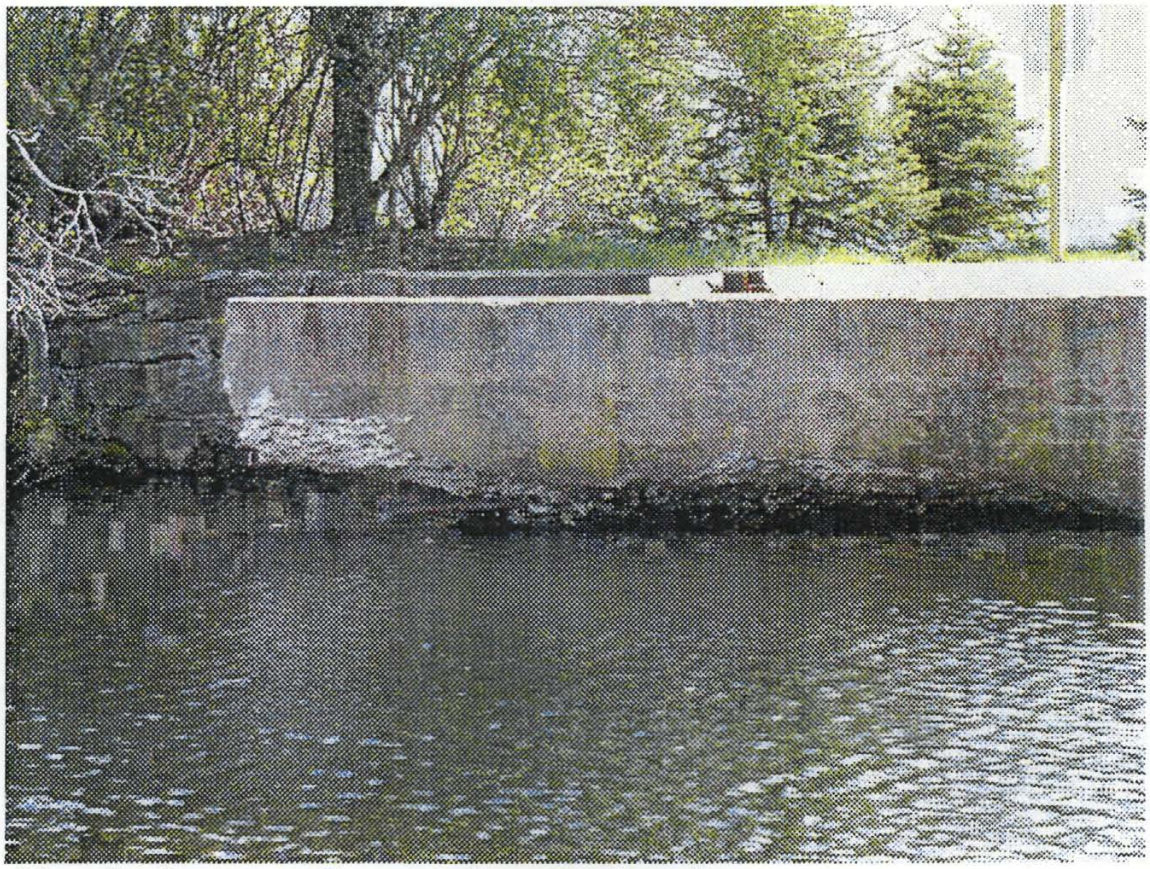


Photo 7 – Concrete spalling on outlet works wingwall.

MANTON DAM
HYDROLOGY AND HYDRAULICS ANALYSIS

1. Summary. Manton Dam's spillway has a capacity of about 1,500 cfs, and can pass the 15-year discharge without overtopping the dam. A backwater reaches the spillway crest during the 80-year flood and submerges it about 0.6 feet during the 100-year event. This backwater only slightly reduces spillway capacity during the 100-year discharge. The dam would be overtopped by an estimated 1.35 feet during the 100-year flood, but the difference in water surface elevations above and below the dam would be less than 3.8 feet because of backwater effects, and a sudden catastrophic failure would be unlikely. However, water flowing over the earth embankment could lead to rapid erosion of the dam and washout of sediments behind it..

2. Dimensions. Available information on this dam came from RIDEM and includes drawings of the dam prepared by the WPA in November 1940, and a blueprint prepared by O. Perry Sarle in November 1944 for spillway concrete reinforcement. These plans show the dam as having the following dimensions. Datum for these elevations appears to be based on arbitrarily setting the spillway to 50.0 feet, and does not appear to be equivalent to NGVD.

Elevation of top of dam – 53-55 ft.
Elevation of spillway crest – 50.0 ft.
Spillway width – 86 ft.
Elevation of spillway toe – 45.0 ft.
Elevation of left wingwall – 54.45 ft.
Elevation of right wingwall – 54.67 ft.
Height of dam – 8-10 ft.
Outlet conduits – 4 by 5 ¼ ft

3. Increased Discharge Capacity. Because of the backwater effects, restoring the capacity of the outlet works would have minimal benefit. With the 100-year backwater below the dam at elevation 64.6 and the upstream pool at the top of the dam elevation 67 feet, discharge through the former two 4 foot by 5.25 foot gates on the left side of the spillway would total 350 cfs. To increase spillway capacity so that it could carry the entire 100-year discharge without overtopping the dam, spillway length would have to be increased from 86 to 150 feet.

4. Flows. Estimated peak flood discharges and water surface elevations for the 10, 50, and 100-year flows at Manton Dam and water surface elevations were taken from the PFIS and are given in table 1. The 10, 50, 100, and 500-year flows were plotted on probability paper and this was used to interpolate the 15-year flow of 1,500 cfs (figure 2). Tailwater elevations were plotted on probability paper, and this plot was used to interpolate that the 80-year tailwater would reach spillway crest elevation of 64 feet (figure 3).

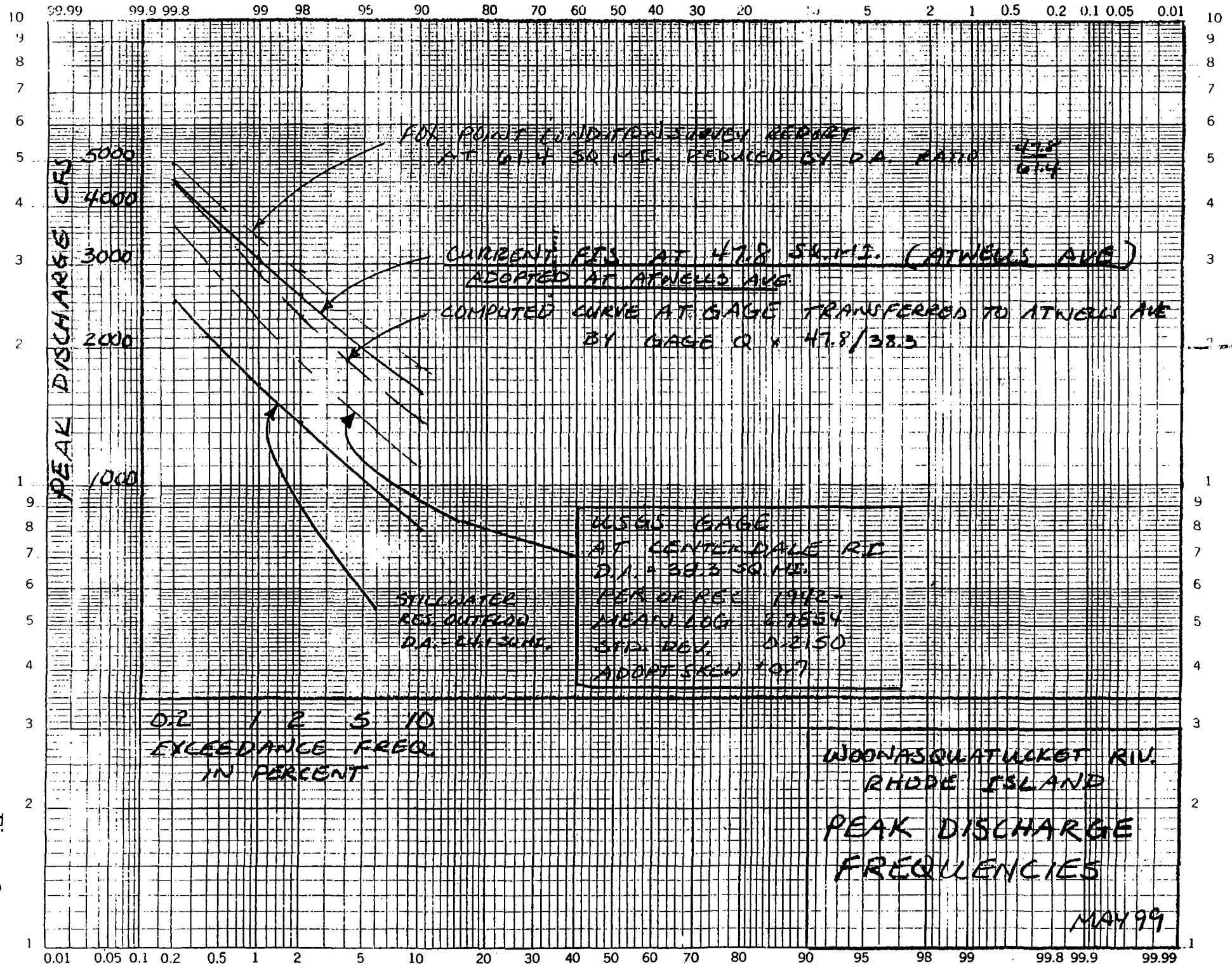
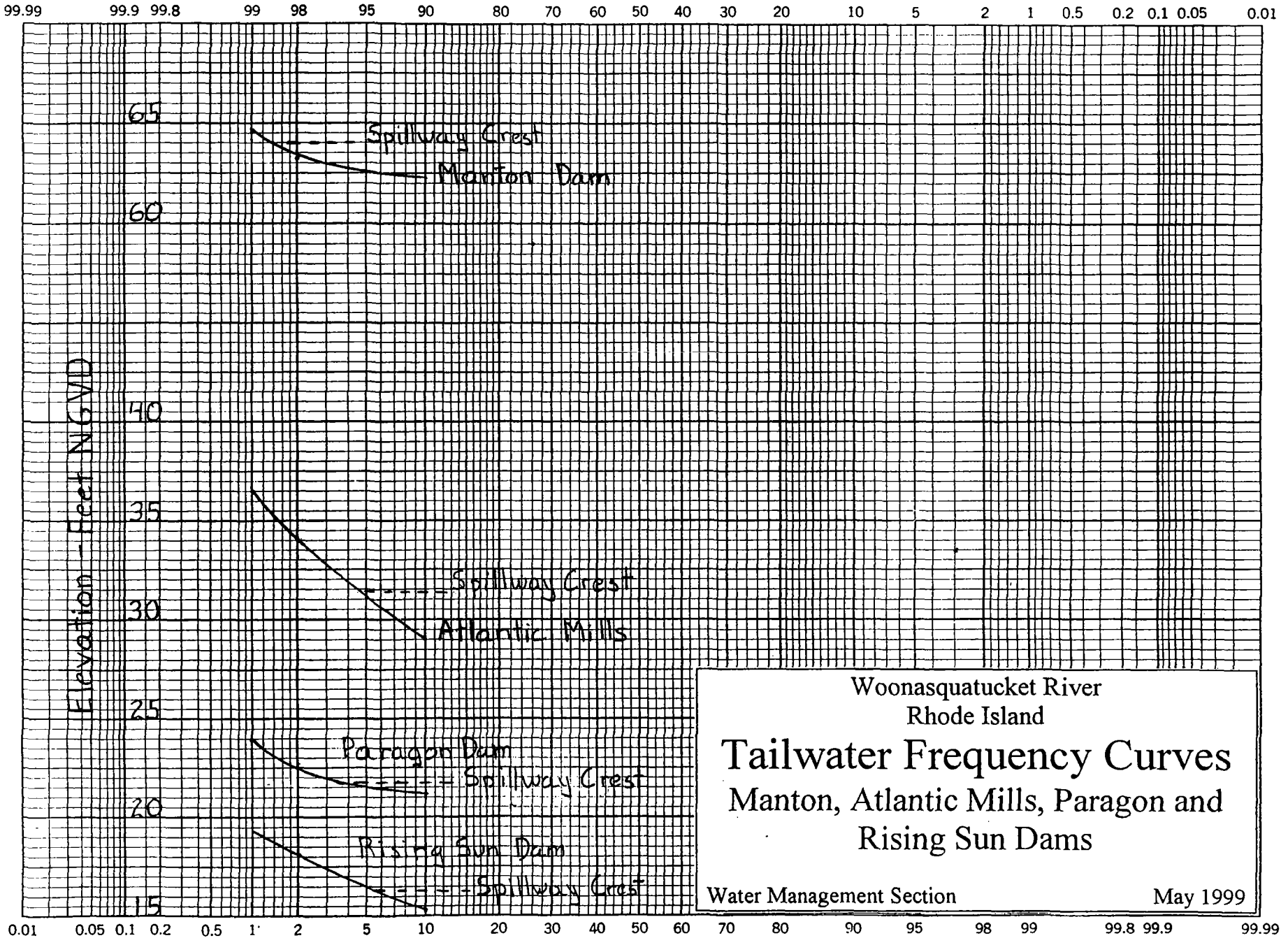

PEAK DISCHARGE CFS
5000
4000
3000
2000
1000
99.99 99.9 99.8 99 98 95 90 80 70 60 50 40 30 20 10 5 2 1 0.5 0.2 0.1 0.05 0.01
0.01 0.05 0.1 0.2 0.5 1 2 5 10 20 30 40 50 60 70 80 90 95 98 99 99.8 99.9 99.99
FOR POUT CONDITIONS SURVEY REPORT AT 61.4 SQ. MI. REDUCED BY D.A. RATIO 47.8/61.4
CURRENT FFS AT 47.8 SQ. MI. (ATWELLS AVE)
ADOPTED AT ATWELLS AVE.
COMPUTED CURVE AT GAGE TRANSFERRED TO ATWELLS AVE BY GAGE Q x 47.8/38.3
SYLVATER RES. OUTFLOW D.A. = 24.1 SQ. MI.
00590 GAGE AT CENTERDALE RD
D.A. = 38.3 SQ. MI.
PER OF REC 1912-
MEAN LOG 2.9654
STD. DEV. 0.2150
ADOPT SKEW +0.7
0.2 1 2 5 10
EXCEEDANCE FREQ. IN PERCENT
WOONASQUATUCKET RIV.
RHODE ISLAND
PEAK DISCHARGE FREQUENCIES
MAY 99

Figure 2

K+E PROBABILITY X 90 DIVISIONS
KEUFFEL & ESSER CO. MADE IN U.S.A.
46 8003



Woonasquatucket River
Rhode Island

Tailwater Frequency Curves

Manton, Atlantic Mills, Paragon and Rising Sun Dams

Water Management Section May 1999

Figure 3

Table 1 Peak Discharges and Water Surface Elevations Manton Dam Approximate Spillway Crest Elevation = 64.0 ft, NGVD Approximate Top of Dam Elevation = 67 ft, NGVD				
Event (Year)	Flow (cfs)	PFIS Water Surface Elev. Upstream of Dam (ft-NGVD)	Corps Estimated Water Surface Elev. Upstream of Dam (ft-NGVD)	PFIS Water Surface Elev. Downstream of Dam (ft-NGVD)
10	1,350	66.8		62.3
50	2,170	67.3		63.3
100	2,600	68.2	68.4	64.6

5. Elevations. Spillway crest elevation of 64.0 feet, NGVD was estimated from a flood profile in the PFIS. Height of the dam above spillway crest was taken from WPA drawings. The top of dam elevation of 67 feet was estimated by adding the 3-foot height above spillway crest to the crest elevation.

6. Spillway Capacity. Spillway capacity was estimated using the standard weir equation. For a condition approaching a broad-crested weir with a sharply down-sloping face, a weir coefficient of 3.4 was selected. With a width of 86 feet, height of 3 feet, and weir coefficient of 3.4, the capacity of the spillway is 1,500 cfs, assuming no backwater effects. Adjustments to spillway capacity to account for effects of submergence of the crest by tailwater conditions were made using figure 5.5 of King and Brater's *Handbook of Hydraulics*. With the 100-year backwater submerging the spillway crest 0.6 feet, spillway capacity is reduced to 1,460 cfs. To pass the 100-year flow with the 100-year backwater, flow over the spillway would be 4.35 feet deep. This would overtop the dam by 1.35 feet; however, flow over the embankments would reduce the upstream water surface, and actual overtopping of the dam would be less than 1.35 feet. Restoring the outlet works capacity would drop the overtopping to about a foot.

7. Comparisons. The PFIS shows the 100-year water surface above the dam as about elevation 68.2 feet, NGVD, while calculations as part of this investigation put it at about 68.4 feet, which is very good agreement. Also, the weir elevation of 64 feet in the PFIS is in fair agreement with the USGS Providence, RI quad sheet (revised 1975) that shows the pool level as 66 feet.

WOONASQUATUCKET RIVER DAM INVESTIGATIONS
RHODE ISLAND

APPENDIX C

ATLANTIC MILLS DAM

INSPECTION CHECKLISTS
PHOTOGRAPHS
AND
HYDROLOGY AND HYDRAULICS ANALYSIS

APPENDIX C –ATLANIC MILLS DAM

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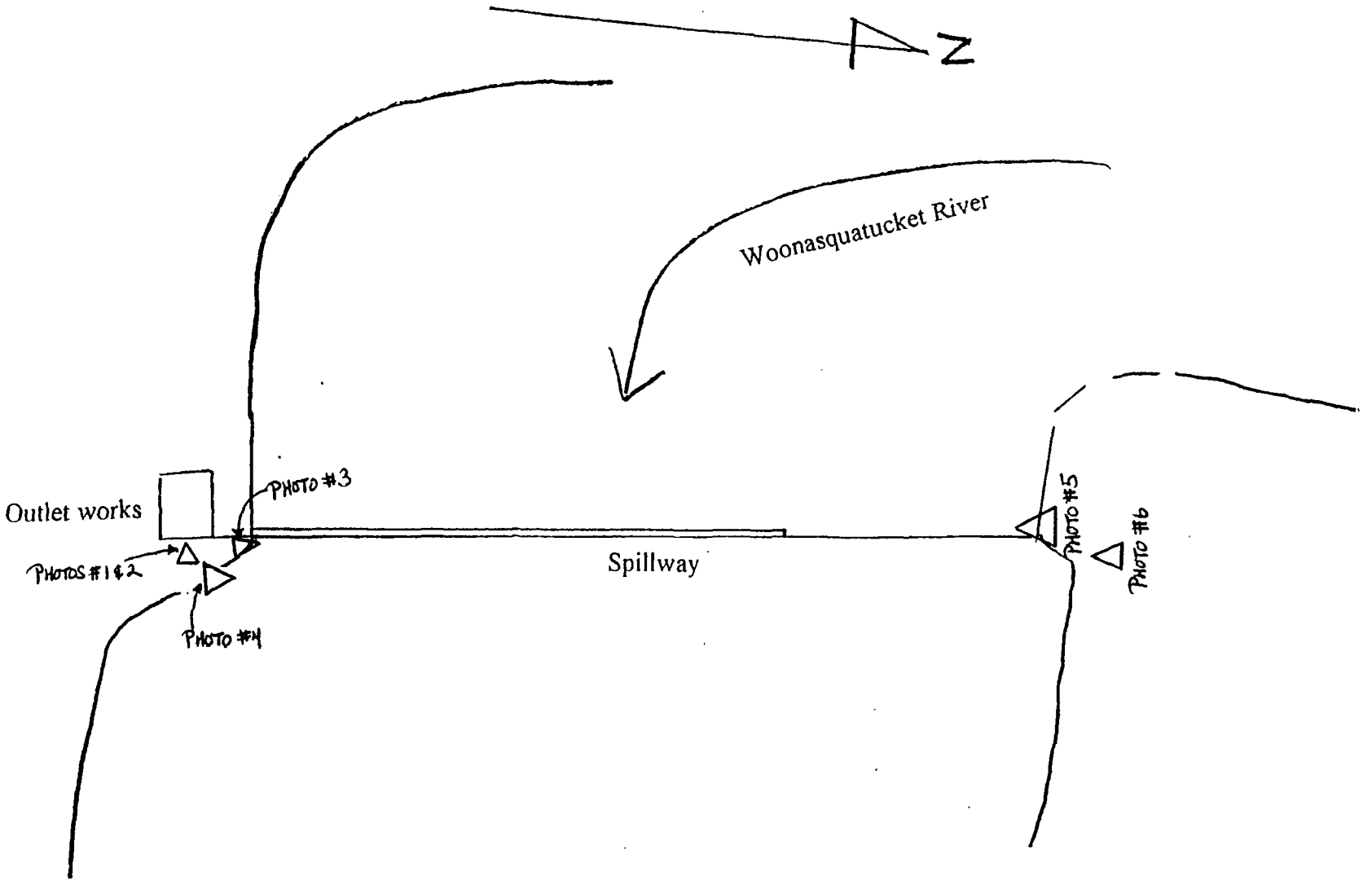
Woonasquatucket River Dams
Inspected in April 1999

TEAM MEMBER CHECKLIST FOR INSPECTION		
AREA EVALUATED	**BY**	**CONDITION**
CONCRETE/STRUCTURAL	**JL**	
OUTLET STRUCTURE		
General Condition		Poor and not operational.
Debris and Vegetation		The opening of the structure is almost completely filled with debris. A number of large trees are growing through the joints of the stones.
Condition of Joints		The joints are in poor condition due to the growth of trees. The stone blocks have shifted and moved up to 4".
SPILLWAY		
General Condition		Good, with some minor deterioration.
Debris and Vegetation		A large telephone pole and some minor tree debris were caught at the right side of the spillway. A large tree growing through the joint at the left abutment wall.
Timber Beams		The 10x10 at the right side is severely weathered and cracked. The 2x8 adjacent to the left abutment is missing.
	JL	

TEAM MEMBER CHECKLIST FOR INSPECTION		
AREA EVALUATED	**BY**	**CONDITION**
CONCRETE/STRUCTURAL	**JL**	
SPILLWAY, CONT'D		
Seepage		Minor seepage through the gaps between the 10x10 and the tree trunk.
Condition of Joints		The joints are in poor condition due to the growth of trees. The stone blocks have shifted and moved up to 6".
	JL	

Atlantic Mills Dam – Photo Locations



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ATLANTIC MILLS DAM INSPECTION

Photo 1: Debris almost completely fills the opening of the outlet structure located at the right side of the spillway.

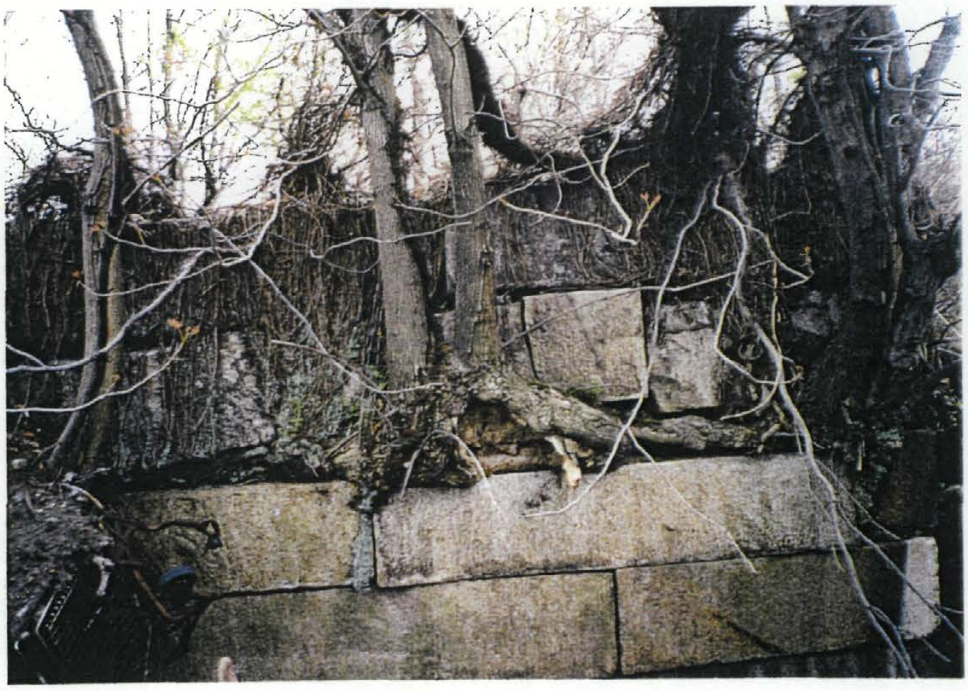


Photo 2: The large stone blocks making up the outlet structure have shifted and moved, up to 4", due to the growth of trees between the joints.

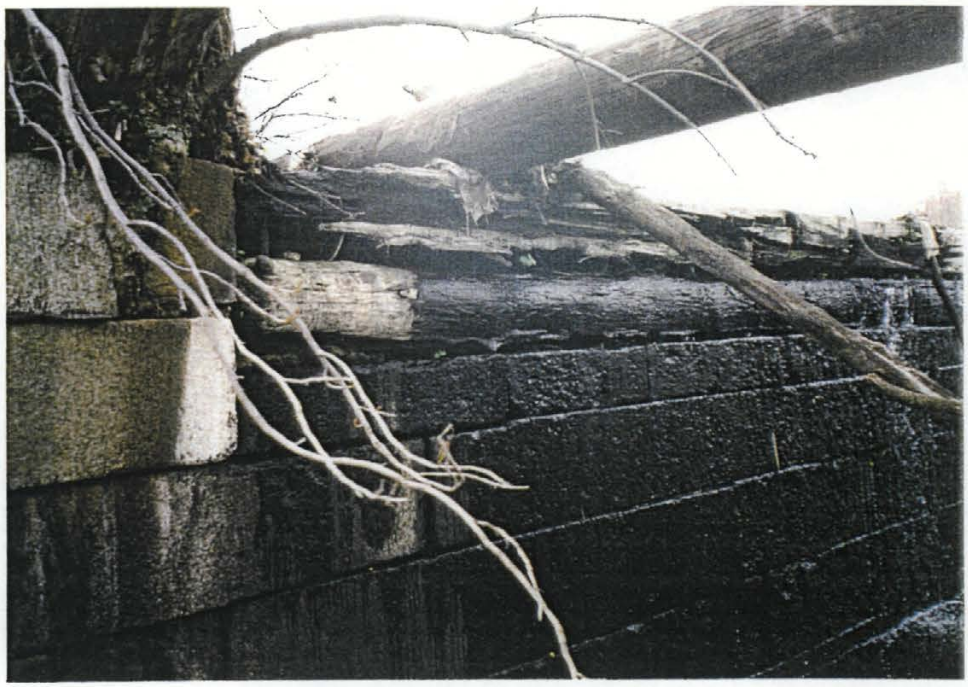


Photo 3: Severely weathered and cracked 10x10 timber at the top of the spillway adjacent to the outlet structure.

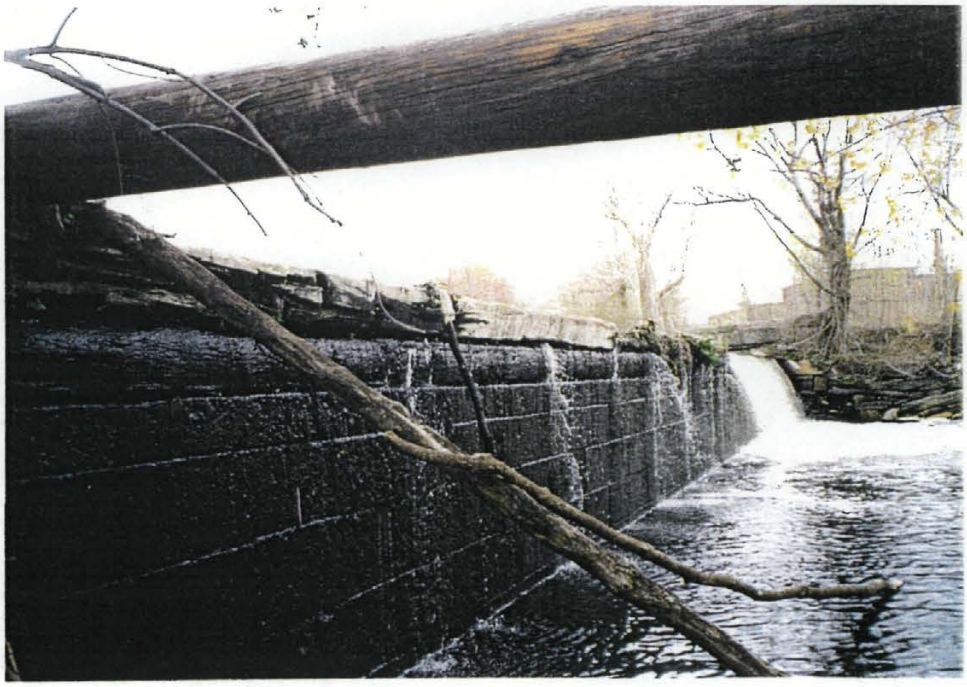


Photo 4: A large telephone pole and other minor tree debris caught at the top of the spillway. Note: seepage through the gaps between the 10x10 and the tree trunk.

ATLANTIC MILLS DAM INSPECTION

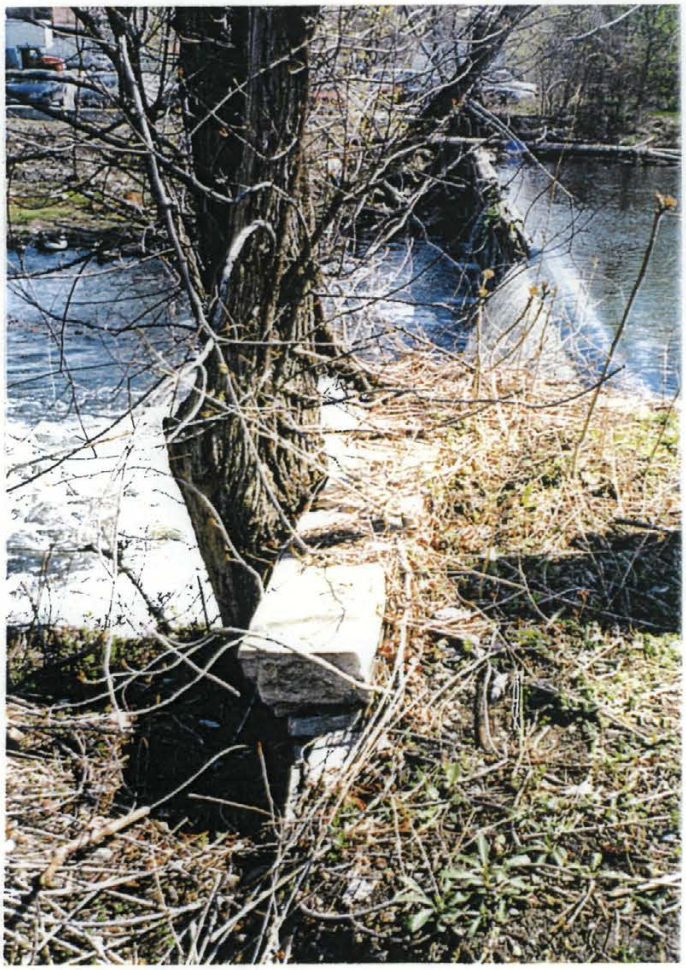


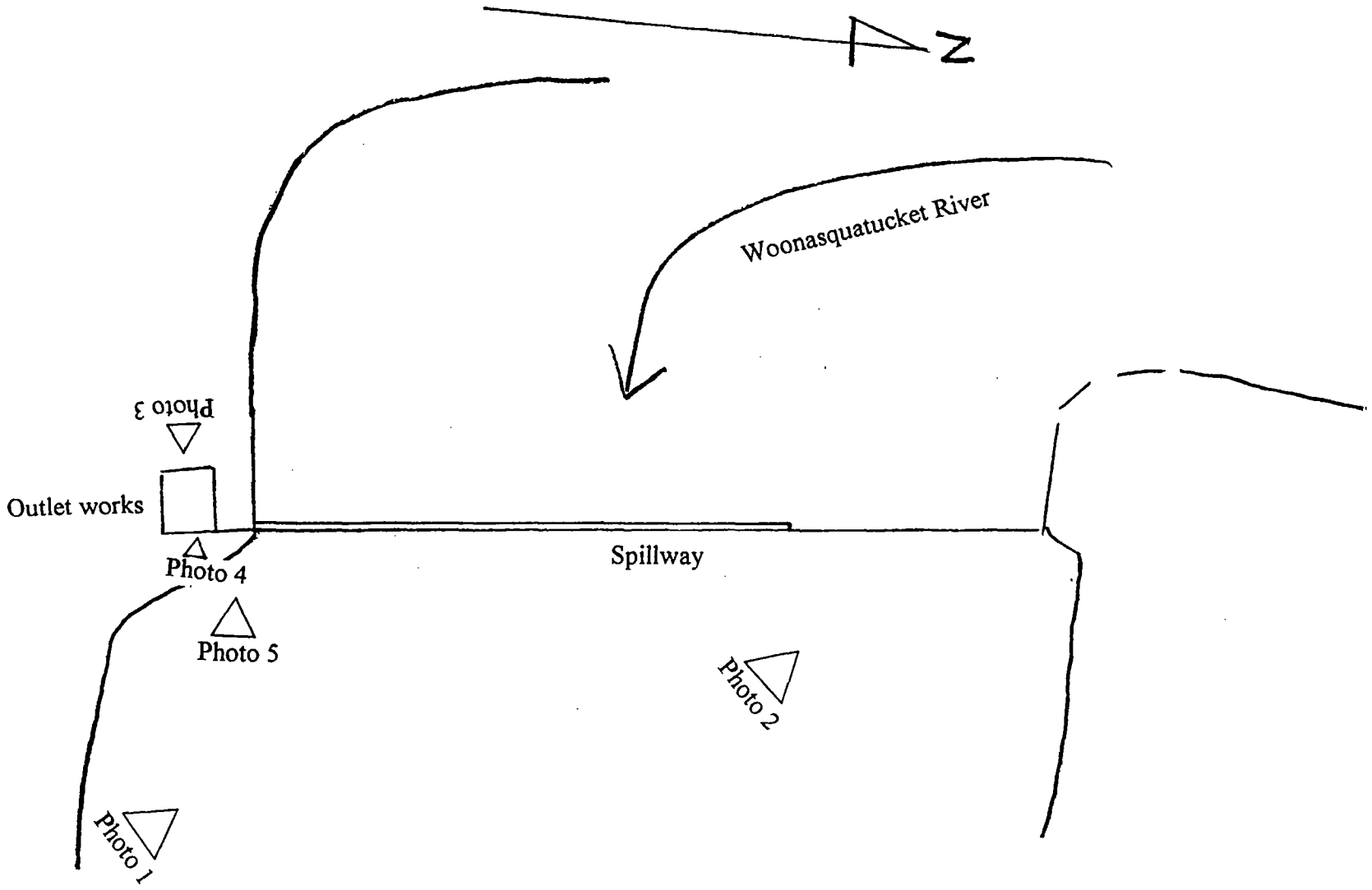
Photo 5: Missing 2x8 timber at the left side of the spillway, allowing water to flow over the spillway.

Photo 6: Movement of up to 6″ at the left abutment due to the growth of a large tree through the joints of the stone blocks.

TEAM MEMBERS CHECK LISTS FOR INSPECTION NO. 1		
AREA EVALUATED	BY	CONDITION
GEOTECHNICAL		
ABUTMENTS		
Condition at Granite Block Structures	PS	Fair to Poor. Trees up to 24-inch diameter and 50 foot high growing in left and right abutment walls.
Condition along right river bank (downstream)		Poor. Block wall has collapsed.
Condition along left river bank (downstream)		Fair to Poor. Significant downward and outward movement of granite block and stone wall.
OUTLET WORKS		
South Gate		
Intake Channel		Submerged and plugged with debris.
Outlet Channel		Partially filled with soil and debris.
Gate		Closed and inoperable.
North Gate		No longer exists or has been filled.
Spillway		
Intake Channel		Submerged. Deposition almost up to spillway crest.
Outlet Channel		Clear.
Weir	PS	Seepage flows through joints in granite block weir.

Team Members Check Lists for Inspection of **Atlantic Mills Dam**		
Area Evaluated	By	Conditions
Hydrology/Hydraulics		
Spillway	TB	Granite block.
Approach Channel		Generally clear of obstructions..
Condition		Fair to good. Telephone pole and other debris on spillway crest
Stilling Basin		None. Appears to discharge to a granite block apron, but flow prevented direct observation.
Discharge Channel		Generally clear – free of major obstructions.
Outlet Works		On right-hand side of spillway.
Inlet		
Channel		Buried under earth fill.
Trash Rack		NA
Emergency Closure		NA
Gates		Buried under earth fill.
Gate Passage		NA
Outlet		Heavily obstructed with debris.
Stilling Basin		NA
Exit Channel		Heavily obstructed with debris.
Instrumentation		None.
Rain Gage		None.
Pool Stage Recorder		None.
Log Boom		None.

Atlantic Mills Dam – Photo Locations



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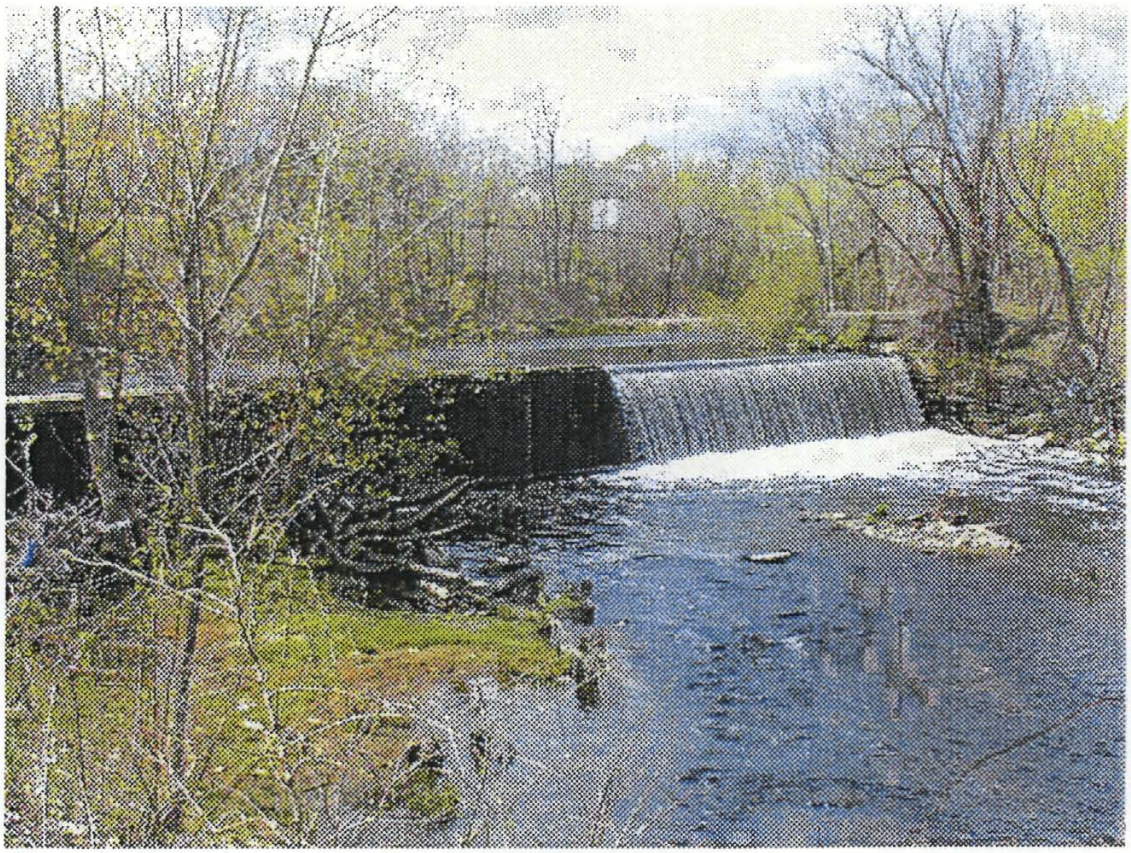

Photo 1 – Overview of dam.

Photo 2 – Left wingwall and water flowing over missing timber on spillway.

Photo 3 – Outlet works are filled in with earth.

Photo 4 – Outlet works are filled with debris and earth.

Photo 5 – Shifted blocks on right embankment and downstream side of outlet works.

ATLANTIC MILLS DAM
HYDROLOGY AND HYDRAULICS ANALYSIS

1. Summary. The Atlantic Mills Dam spillway has a capacity of about 1,900 cfs, equivalent to the 15-year discharge. A backwater reaches the spillway crest during the 20-year discharge and submerges the dam during the 100-year discharge. Because of this backwater, flow over the spillway would be 6.5 feet deep—about 2.8 feet over the top of the dam—to pass the 100-year discharge of 3,090 cfs. However, even though the dam would be overtopped, the difference in water surface elevations above and below the dam would not be large because of backwater effects. There would be only 1.3 feet of difference between upstream and downstream water levels for the 100-year flood, and a sudden catastrophic failure would be unlikely. However, erosion would occur along the embankments and failure of the right (south) abutment is possible and could lead to washout of sediments behind the dam.

2. Dimensions. The WPA drawing shows the dam as having the following dimensions. Datum for these elevations appears to be based on arbitrarily setting the spillway to 50.0 feet, and does not appear to be equivalent to NGVD.

Elevation of top of dam – 52.69 - 52.89 ft.
Elevation of spillway crest – 50.0 ft.
Spillway width – 98 ft.
Elevation of spillway toe – 40.62 ft.
Elevation of left wingwall – 52.89 ft.
Elevation of right wingwall – 52.69 ft.
Height of dam – 12 ft.
Outlet conduits – 5.8' wide by 4.5' high

The draft report, "Hydrodynamic Modeling Site Survey, Woonasquatucket River, Providence, Rhode Island" dated December 31, 1998 for the Corps of Engineers, New England Division by Battelle, includes survey data for Atlantic Mills Dam (which is labeled "Unnamed Dam" in their report). Spillway width was measured at 100.0 feet. Table 1 contains survey data from this report for stations running from the left to right abutments (looking downstream).

3. Flows. Estimated peak flood discharges at Atlantic Mills Dam and water surface elevations were taken from the PFIS and are given in table 2. Tailwater elevations were plotted on probability paper, and this plot was used to interpolate the frequency of the tailwater that would reach spillway crest elevation (figure 2).

TABLE 1

ATLANTIC MILLS DAM
CROSS-SECTION DATA FROM BATTELLE REPORT
(All elevations are in feet and referenced to NGVD)

Station	Description	Elevation
0+00	Ground at river edge	35.3
0+25	Natural ground	34.3
0+50	Natural ground	34.2
0+75	Natural ground	34.9
1+00	Natural ground	34.9
1+08	Top of granite block wall	35.2
1+08	Top of spillway at granite block wall	31.3
1+08	Toe of spillway at granite block wall	21.7
1+58	Top of spillway at centerline of dam	32.3
1+58	Toe of spillway at centerline of dam	21.2
2+08	Top of spillway at granite block wall	32.1
2+08	Top of spillway at granite block wall	23.8
2+08	Top of granite block wall	35.0
2+33	Ground at bituminous concrete parking	34.2
2+58	Ground at bituminous concrete parking	33.5
2+83	Ground at bituminous concrete parking	33.6
3+08	Ground at bituminous concrete parking	33.8
3+33	Toe of slope at I-195 access ramp	33.8
3+58	Ground on slope of I-195 access ramp	37.3

4. Elevations. There are two spillway crest elevations in the Battelle survey. The lower section near the left abutment has an elevation of 31.3 feet, NGVD. The rest of the spillway with the logs in place has a crest elevation ranging from 32.1 to 32.3 feet; for the hydraulic analyses, this section was assume to be at 32.2 feet, NGVD. By comparison, a spillway crest elevation of 31.4 feet, NGVD was estimated from a flood profile in the PFIS; this is essentially the same as the lower spillway crest elevation in the Battelle report.

Battelle data shows the top of the left abutment as elevation 35.2 and the right abutment as 35.0 feet, NGVD. For the hydraulic analyses, the top of the dam was taken as the lower of the two—35.0 feet. By comparison, elevation of the top of the dam was estimated by adding the 2.9-foot height above spillway crest from the WPA drawings to the crest elevation of 31.4 feet in the PFIS, giving an elevation of 34.3 feet, which was not too far from survey results.

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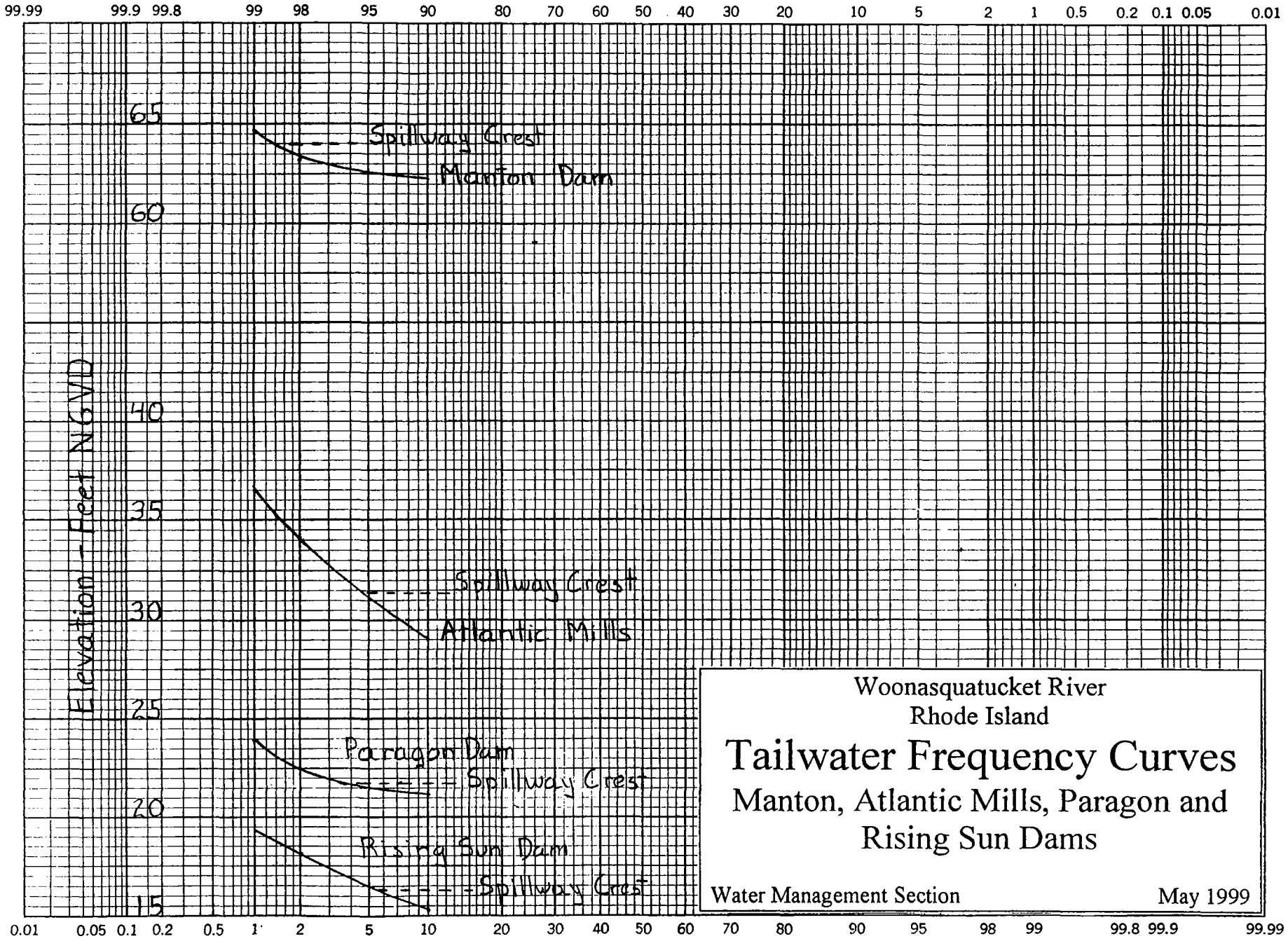

Woonasquatucket River
Rhode Island

Tailwater Frequency Curves

Manton, Atlantic Mills, Paragon and Rising Sun Dams

Water Management Section May 1999

Figure 2

5. Spillway Capacity. Spillway capacity was estimated using the standard weir equation. For a condition approaching a broad-crested weir with a vertical downstream face, a weir coefficient of 3.3 was selected. With a width of 100 feet, height of 3.7 feet, and weir coefficient of 3.3, the capacity of the spillway is 1,900 cfs for a condition with no backwater effects, about equal to the 15-year discharge. Adjustments to spillway capacity to account for effects of submergence of the crest by tailwater conditions were made using figure 5.5 of King and Brater's *Handbook of Hydraulics*. During the 100-year flood with a backwater elevation of 36.5 feet, water would have to be at elevation 37.8 feet (6.5 feet over the lower spillway crest) to pass the peak discharge.

Table 2
Peak Discharges and Water Surface Elevations
Atlantic Mills Dam
Spillway Crest Elevations = 31.3 (lower) and 32.2 (upper) ft, NGVD
Top of Dam Elevation = 35.0 ft, NGVD

Event (Year)	Flow (cfs)	PFIS Water Surface Elev. Upstream of Dam (ft-NGVD)	Corps Estimated Water Surface Elev. Upstream of Dam (ft-NGVD)	PFIS Water Surface Elev. Downstream of Dam (ft-NGVD)
10	1,590	34.5		29.0
50	2,570	35.5		34.0
100	3,090	37.0	37.8	36.5

6. Comparisons. The PFIS shows the 100-year water surface above the dam as about elevation 37.0 feet, NGVD, while calculations as part of this investigation put it at about 37.8 feet. This difference is likely due to the PFIS using the lower spillway crest elevation for the entire spillway. Corps analyses used the more conservative assumption that the boards on the spillway crest stayed in place causing higher water surface elevations.

7. Increased Discharge Capacity. Because the dam is overtopped by backwater during the 100-year flow, neither restoring the capacity of the outlet works nor increasing the length of the spillway can prevent overtopping of the dam unless the top of the dam itself is raised.

WOONASQUATUCKET RIVER DAM INVESTIGATIONS
RHODE ISLAND

APPENDIX D

PARAGON DAM

INSPECTION CHECKLISTS
PHOTOGRAPHS
AND
HYDROLOGY AND HYDRAULICS ANALYSIS

APPENDIX D – PARAGON DAM

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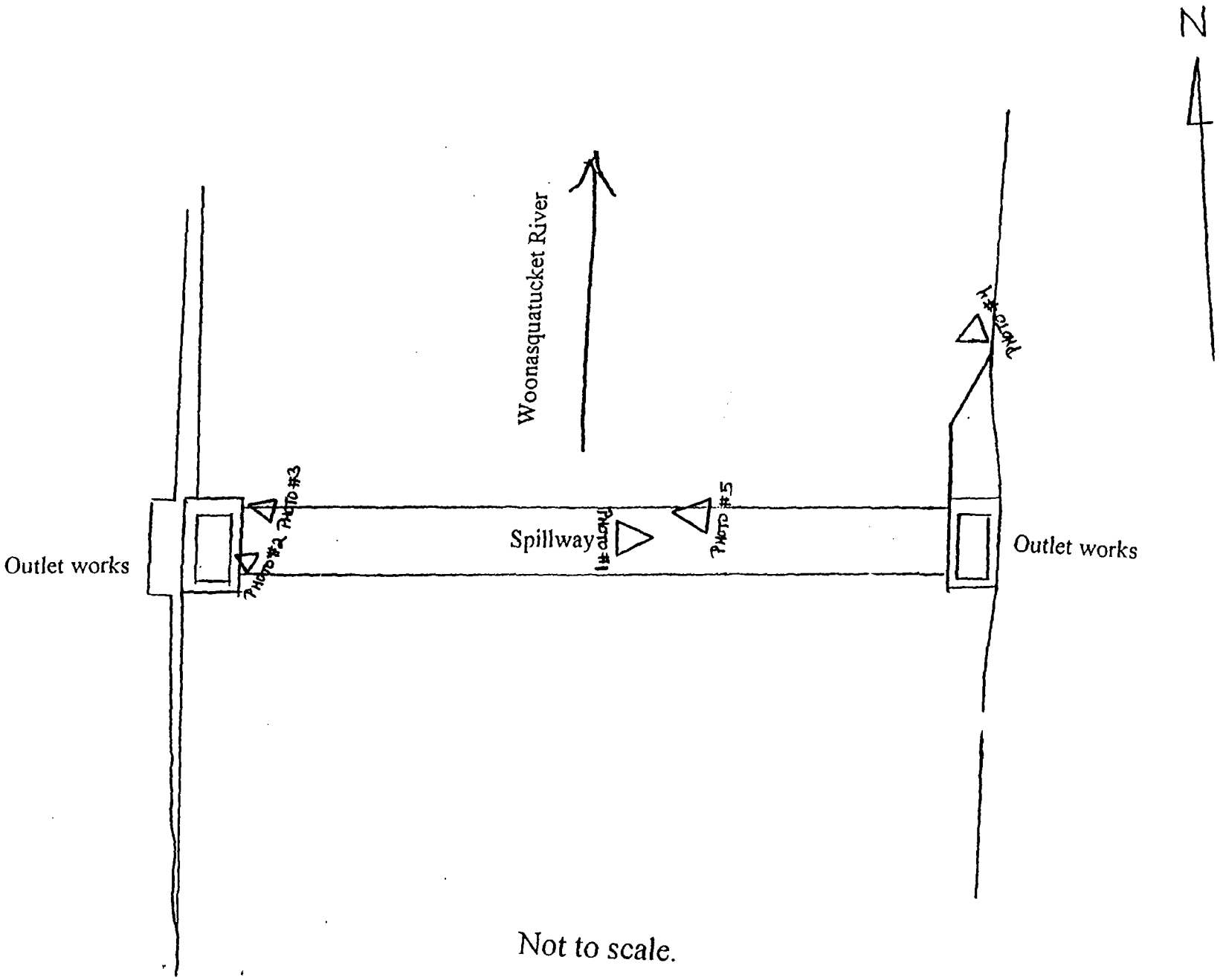
Woonasquatucket River Dams
Inspected in April 1999

TEAM MEMBER CHECKLIST FOR INSPECTION		
AREA EVALUATED	**BY**	**CONDITION**
CONCRETE/STRUCTURAL	**JL**	
RIGHT OUTLET STRUCTURE		
General Condition		Good, with the gate in the raised position.
Debris		Debris in the outlet channel allowed very little flow through the structure.
Cracks		Numerous hairline cracks with efflorescence on the left wall of the outlet structure.
LEFT OUTLET STRUCTURE		
General Condition		Good. Gate is missing and water is flowing rapidly through the structure.
Concrete deterioration		Severe deterioration noted at the timber gate guides. A spall, measuring 4sf x 1" deep, noted downstream of the weir. Moderate abrasion noted at both walls.
Cracks		Numerous cracks with efflorescence at the right wall.
SPILLWAY		
General Condition	**JL**	Fair, with severe and extensive spalling of the downstream face and minor to moderate abrasion of the upstream face.

TEAM MEMBER CHECKLIST FOR INSPECTION		
AREA EVALUATED	**BY**	**CONDITION**
CONCRETE/STRUCTURAL	**JL**	
SPILLWAY, CONT'D		
Concrete Deterioration		Severe and extensive spalling, up to 8" deep, of the downstream face of the spillway. Crest is generally in good condition with some areas of unsound concrete.
Cracks		Up to $^1/_4$" thick, at every $^1/_3$ points of the spillway crest.
	JL	

Paragon Dam – Photo Locations



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PARAGON DAM INSPECTION

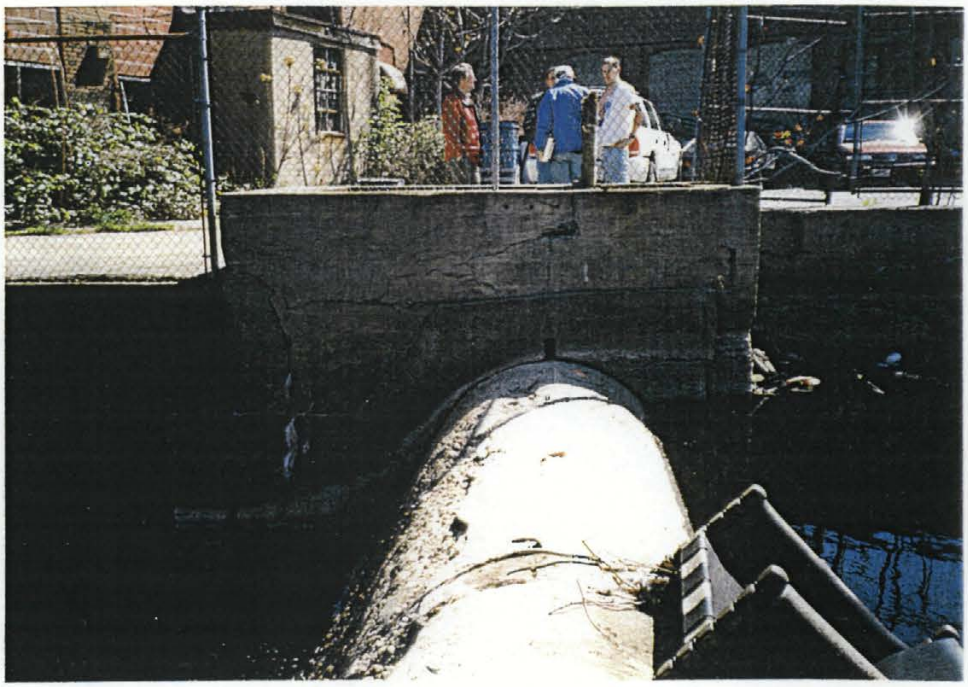


Photo 1: Numerous hairline cracks with efflorescence on the left wall of the outlet structure.

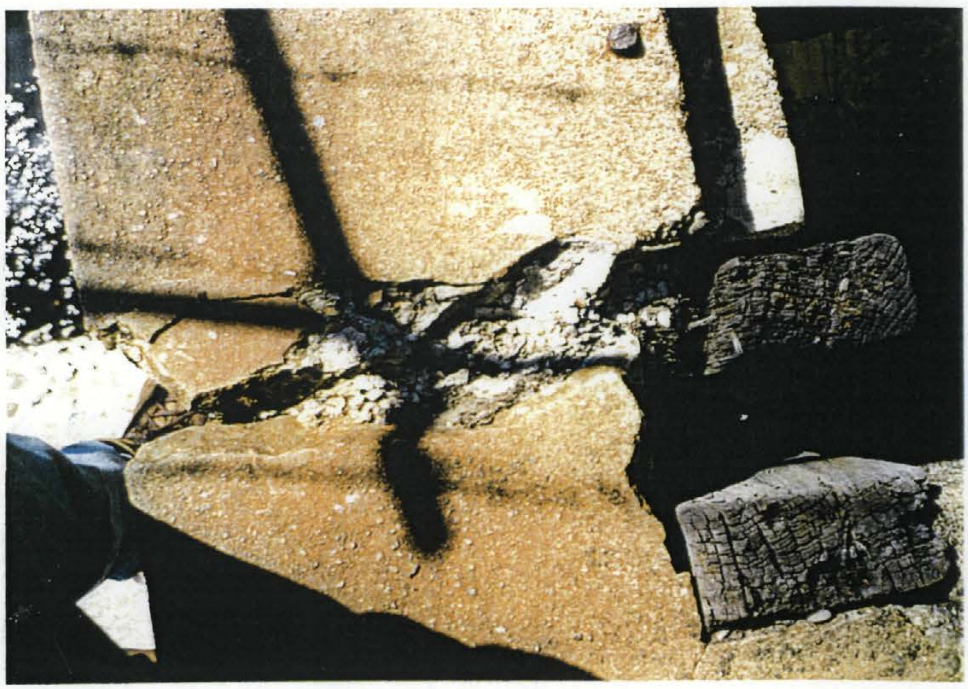


Photo 2: Severe concrete deterioration of the concrete at the timber gate guides of the left outlet structure.

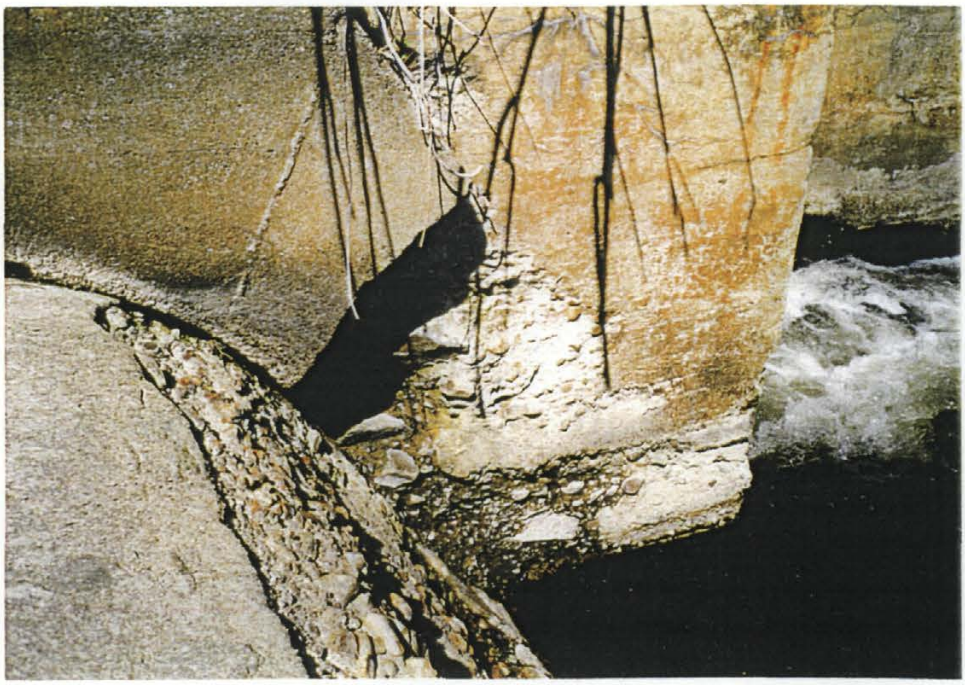


Photo 3: Downstream of the spillway weir, a 4sf x 1" deep spall at the right wall of the left outlet structure. *Note: there are numerous cracks with efflorescence at this wall.*

Photo 4: Downstream view of the spillway. *Note: the debris upstream of the spillway.*

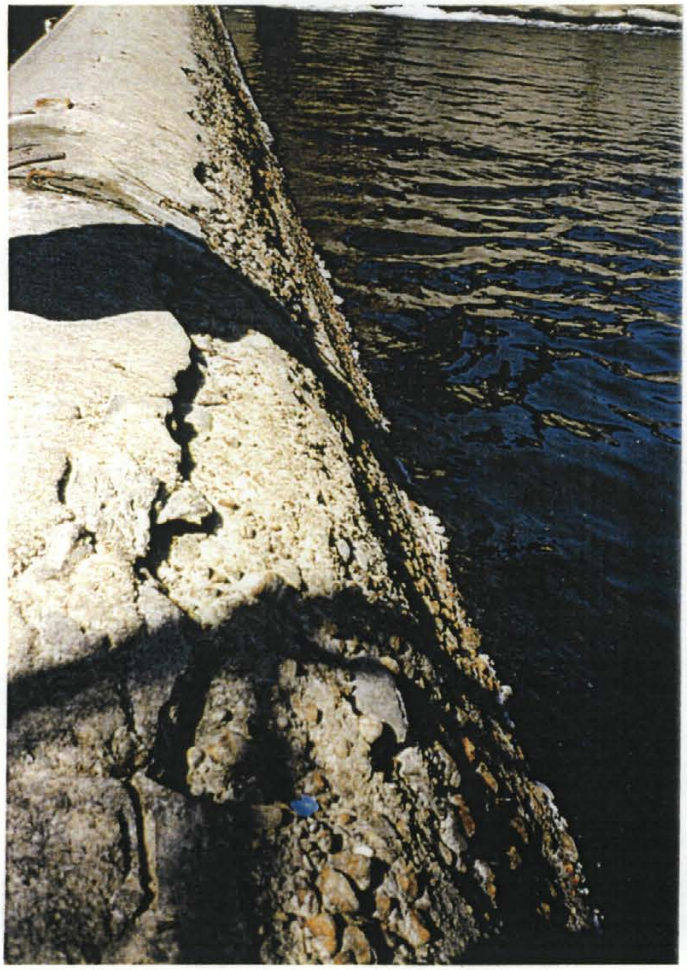
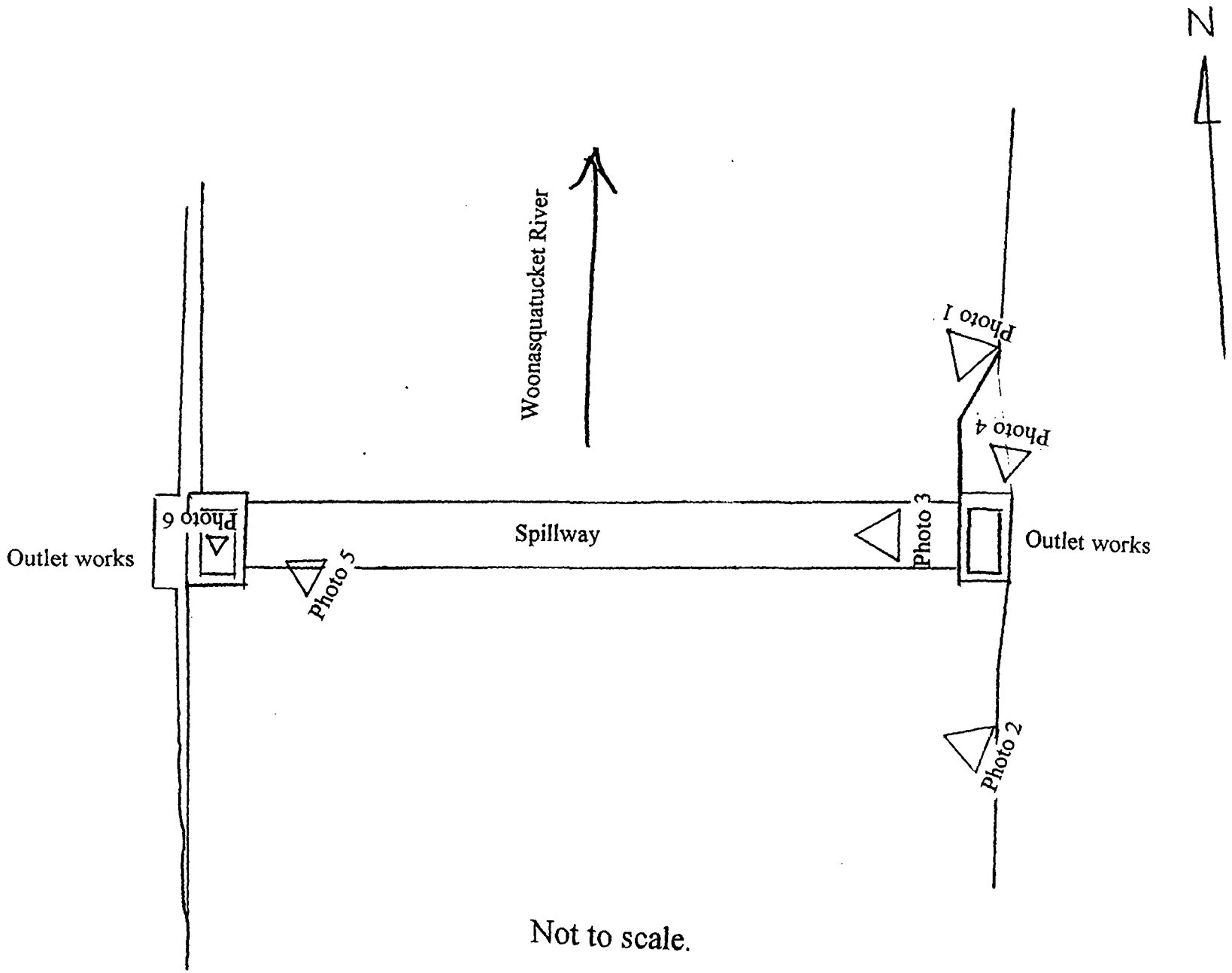


Photo 5: Severe and extensive spalling, measuring up to 8″ deep, on the downstream face for the entire length of the spillway.

TEAM MEMBERS CHECK LISTS FOR INSPECTION NO. 1		
AREA EVALUATED	BY	CONDITION
GEOTECHNICAL		
ABUTMENTS		
Condition at Concrete Structures	PS	Good. No significant erosion noted.
Condition along right river bank		Good. A few cracks and slight erosion in concrete wall.
Condition along left river bank		Fair to Good. Vegetation growing in upstream cut stone wall. A few cracks and slight erosion in downstream concrete wall.
OUTLET WORKS		
East Gate		
Intake Channel		Clear.
Outlet Channel		Clear.
Gate		Open and clogged with debris.
West Gate		
Intake Channel		Clear.
Outlet Channel		Clear.
Gate		Open and missing.
Spillway		
Intake Channel		Submerged. Minimal deposition. Some debris visible.
Outlet Channel		Island approximately 40 feet downstream (80 feet across river by 15 feet down river).
Weir	PS	Surficial concrete has been eroded.

Team Members Check Lists for Inspection of **Paragon Dam**		
Area Evaluated	By	Conditions
Hydrology/Hydraulics		
Spillway	TB	Concrete ogee-shaped.
Approach Channel		Generally clear of obstructions. Granite block wall on right bank, natural channel on left.
Condition		Fair to good. Minor debris on spillway crest.
Stilling Basin		None. Appears to discharge to a concrete apron, but flow prevented direct observation.
Discharge Channel		Generally clear – free of major obstructions.
Outlet Works (1)		On right-hand side of spillway.
Inlet		
Channel		Obstructed with debris.
Trash Rack		None.
Emergency Closure		Inoperable
Gates		Wooden, probably inoperable.
Gate Passage		Appears inoperable.
Outlet		
Stilling Basin		None. Discharges to spillway apron.
Exit Channel		Partially obstructed with debris.
Outlet Works (2)		On left side of spillway.
Inlet		
Channel		Clear
Trash Rack		None.
Emergency Closure		None.
Gates		Gates removed.
Gate Passage		NA.
Outlet		
Stilling Basin		None. Discharges to spillway apron.
Exit Channel		Unobstructed.
Instrumentation		None.
Rain Gage		None.
Pool Stage Recorder		None.
Log Boom		None.

Paragon Dam – Photo Locations



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Paragon Dam – 28 April 1999

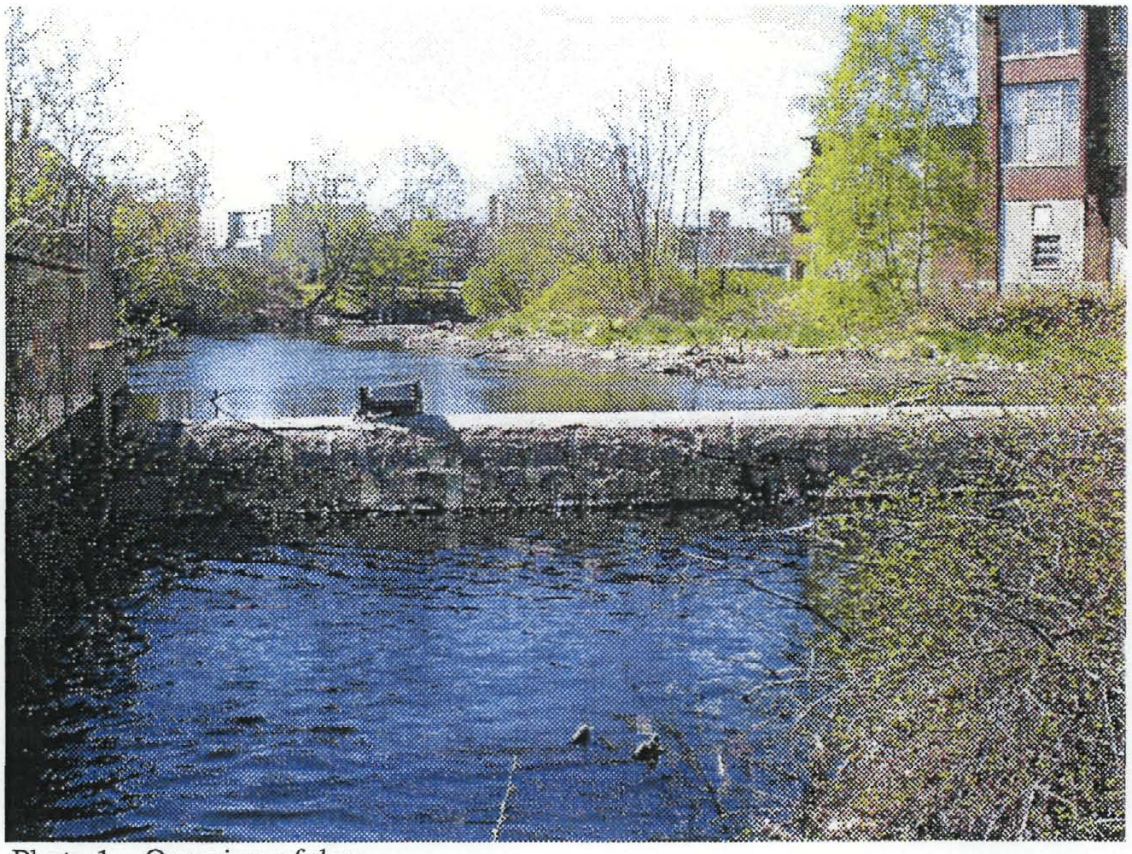

Photo 1 – Overview of dam.

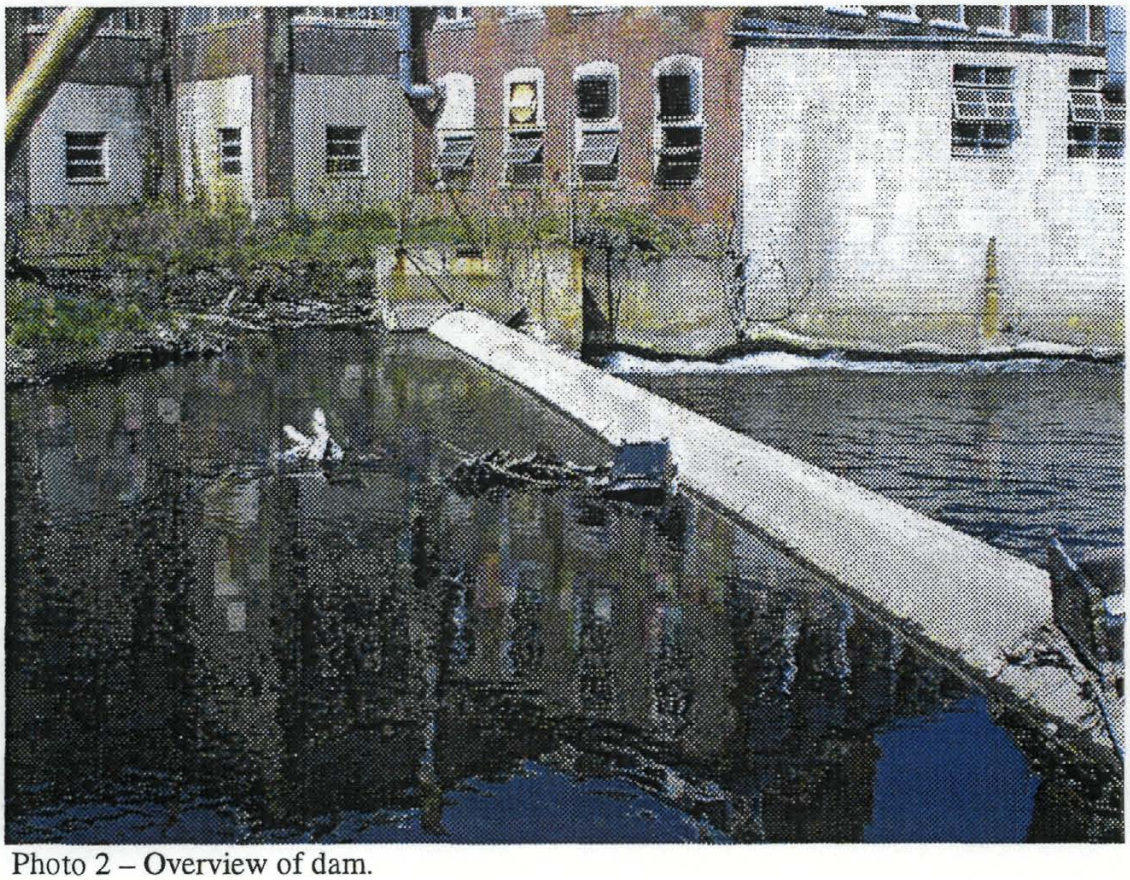

Photo 2 – Overview of dam.

Photo 3 – Spillway from right bank.

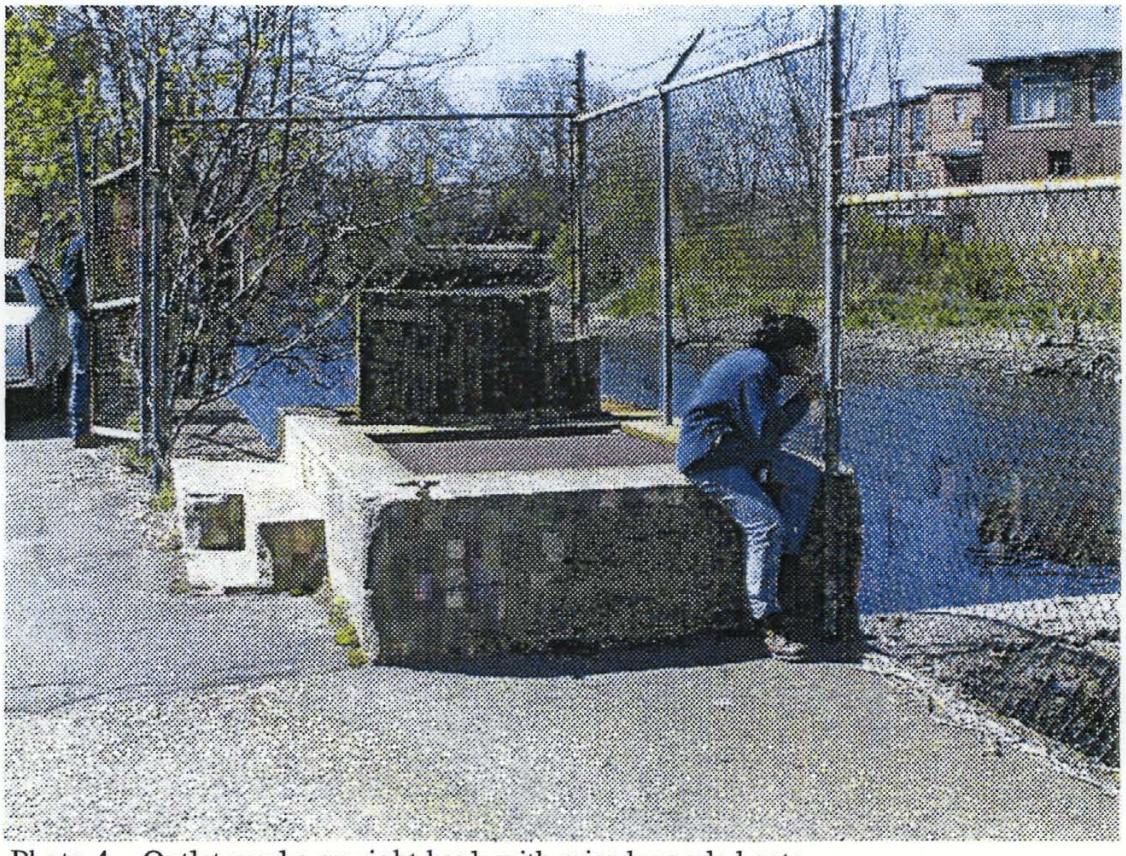

Photo 4 – Outlet works on right bank with raised wooded gate.

Photo 5 – Outlet works on left side of spillway.

Photo 6 – Inside outlet works on left side of spillway.

PARAGON DAM
HYDROLOGY AND HYDRAULICS ANALYSIS

1. Summary. The spillway at Paragon Dam can pass the 50-year peak discharge, but the dam will be overtopped by over half a foot during the 100-year flood. For events equal to or greater than the 30-year flood, a backwater will submerge the spillway. Even though the dam is overtopped during the 100-year flood, the difference in water surface elevations above and below the dam would not be large, and a sudden catastrophic failure would be unlikely. Head drop across the dam would be 3.2 feet for the 50-year flood and 2.6 feet for the 100-year. Furthermore, the masonry walls on either side of the dam mean that a gradual failure of the dam due to erosion of unprotected abutments is also unlikely.

2. Dimensions. The WPA drawing shows the dam as having the following dimensions. Datum for these elevations appears to be based on arbitrarily setting the spillway to 50.0 feet, and does not appear to be equivalent to NGVD.

Elevation of top of dam – 54 ft.
Elevation of spillway crest – 50.0 ft.
Spillway width – 96 ft.
Elevation of spillway toe – 44.49 ft.
Elevation of left wingwall – 54 ft.
Elevation of right wingwall – 54 ft.
Height of dam – 5.5 ft.
Outlet conduits – 4.8' high by 4.0' wide

The draft report, "Hydrodynamic Modeling Site Survey, Woonasquatucket River, Providence, Rhode Island" dated December 31, 1998 for the Corps of Engineers, New England Division by Battelle, includes survey data for Paragon Dam. Spillway width was measured at 95.4 feet. Table 1 contains survey data from this report for stations running from the left to right abutments (looking downstream).

3. Flows. Estimated peak flood discharges at Paragon Dam and water surface elevations were taken from the PFIS and are given in table 2. Tailwater elevations were plotted on probability paper, and this plot was used to interpolate the frequency of the tailwater that would reach spillway crest elevation (figure 2).

4. Elevations. Spillway crest elevation of 21.8 feet, NGVD was taken from the Battelle report. Top of dam elevation of 25.8 was taken from the elevation of the top of concrete outlet works Battelle report. By comparison, a spillway crest elevation of 21.6 was estimated from a flood profile in the PFIS. The top of dam elevation of 25.6 feet was estimated by adding the 4-foot height above spillway crest in the WPA drawing to the crest elevation of 21.6 feet. These numbers are very close to survey results in the Battelle report.

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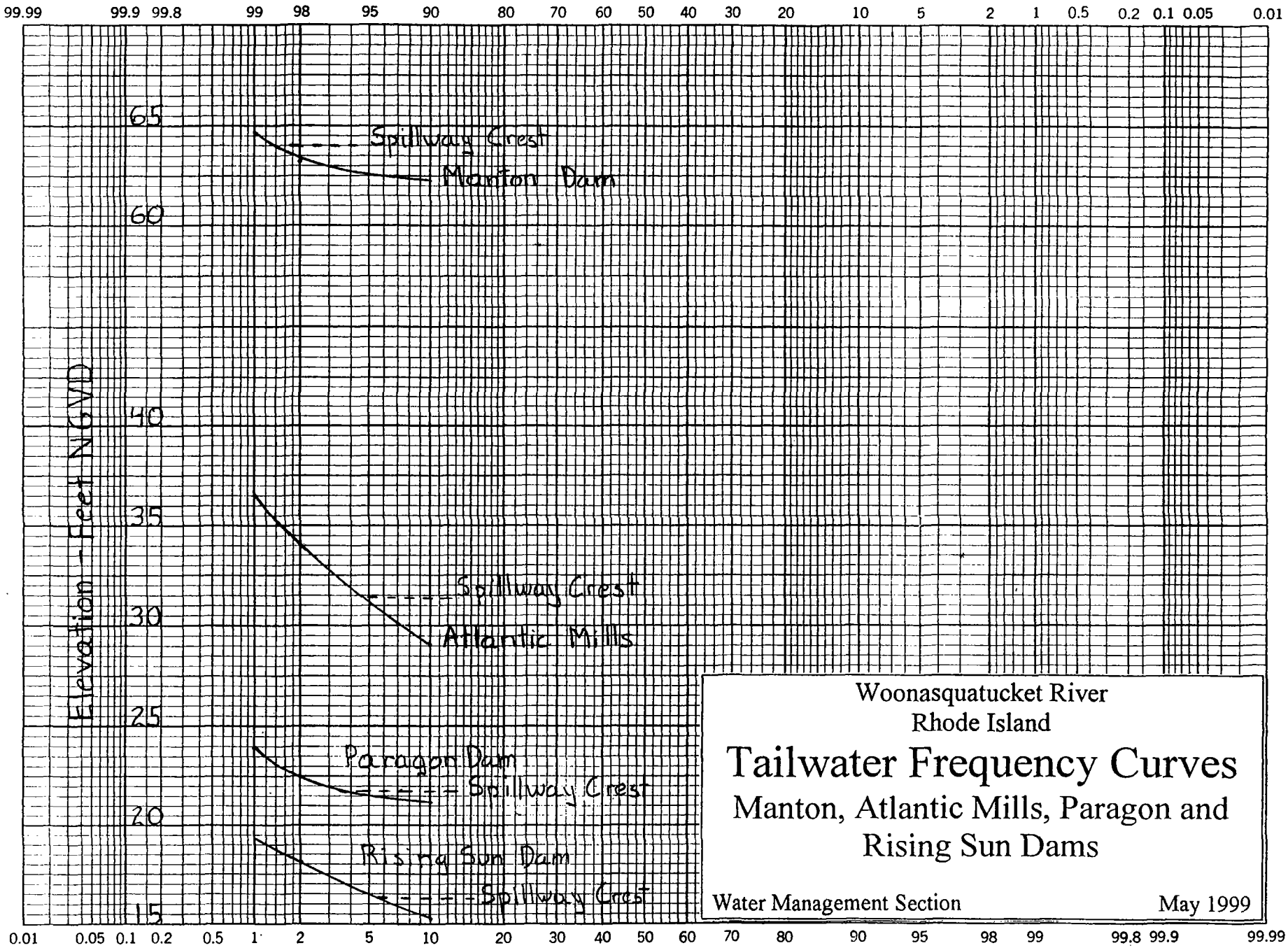

Woonasquatucket River
Rhode Island

Tailwater Frequency Curves

Manton, Atlantic Mills, Paragon and Rising Sun Dams

Water Management Section May 1999

Figure 2

TABLE 1

PARAGON DAM
CROSS-SECTION DATA FROM BATTELLE REPORT
(All elevations are in feet and referenced to NGVD)

Station	Description	Elevation
0+00	Ground at factory wall	26.7
0+25	Top of concrete outlet works	25.8
0+25	Toe of concrete outlet works	16.3
0+25	Top of spillway at outlet works	21.7
0+25	Toe of spillway at outlet works	16.3
0+50	Top of spillway	21.6
0+50	Toe of spillway	16.2
0+75	Top of spillway at centerline of dam	21.8
0+75	Toe of spillway at centerline of dam	16.2
1+00	Top of spillway	21.8
1+00	Toe of spillway	16.0
1+25	Top of spillway at outlet works	21.8
1+25	Toe of spillway at outlet works	16.3
1+25	Top of concrete outlet works	25.8
1+25	Toe of concrete outlet works	16.3
1+50	Ground at bituminous concrete parking	24.0
1+75	Ground at bituminous concrete parking	24.0
2+00	Ground at bituminous concrete parking	24.5

Table 2
Peak Discharges and Water Surface Elevations
Paragon Dam
Spillway Crest Elevation = 21.8 ft, NGVD
Top of Dam Elevation = 25.8 ft, NGVD

Event (Year)	Flow (cfs)	PFIS Water Surface Elev. Upstream of Dam (ft-NGVD)	Corps Estimated Water Surface Elev. Upstream of Dam (ft-NGVD)	PFIS Water Surface Elev. Downstream of Dam (ft-NGVD)
10	1,590	23.6		21.2
50	2,570	25.3	25.7	22.5
100	3,090	25.9	26.5	23.9

5. Spillway Capacity. Spillway capacity was estimated using the standard weir equation. For a weir that is close to an ogee shape, a coefficient of 3.7 was selected. With a width of 95.4 feet, height of 4 feet, and weir coefficient of 3.7, the capacity of the spillway is

2,800 cfs assuming no backwater effects. Adjustments to spillway capacity to account for effects of submergence of the crest by tailwater conditions were made using figure 5.5 of King and Brater's *Handbook of Hydraulics*. With 2.1 feet of backwater, as estimated by the PFIS, spillway capacity is reduced to 2,300 cfs. The peak 50-year discharge of 2,570 cfs creates a backwater at the dam of 0.7 feet. Under these conditions, spillway capacity is about 2,700 cfs, and the spillway can pass about the peak discharge from the 50-year flood without overtopping the dam. The dam will be overtopped by about 0.7 feet during the peak 100-year discharge if only spillway capacity is considered. If the capacity of the left outlet works, which were discharging during the April 1999 inspection, is included, the 100-year discharge overtops the dam by about 0.6 feet.

6. Comparisons. The PFIS shows the 100-year water surface above the dam as about elevation 25.9 feet, NGVD, while calculations as part of this investigation put it at about 26.5 feet, which is fairly good agreement. If the capacity of the open outlet works on the left side of the dam are considered, the Corps' estimated 100-year water surface drops to 26.4 feet.

7. Increased Discharge Capacity. Because of the large tailwater effects and minimal depth of overtopping, restoring the full capacity of the outlet works would have little effect. With the 100-year tailwater and the pool at the top of the dam, discharge through the two 4 foot by 4 foot gates would equal 220 cfs. For the spillway alone to be able to pass the 100-year flood without over overtopping the dam, it would have to be lengthened about 25 percent.

WOONASQUATUCKET RIVER DAM INVESTIGATIONS
RHODE ISLAND

APPENDIX E

RISING SUN DAM

INSPECTION CHECKLISTS
PHOTOGRAPHS
AND
HYDROLOGY AND HYDRAULICS ANALYSIS

APPENDIX E –RISING SUN DAM

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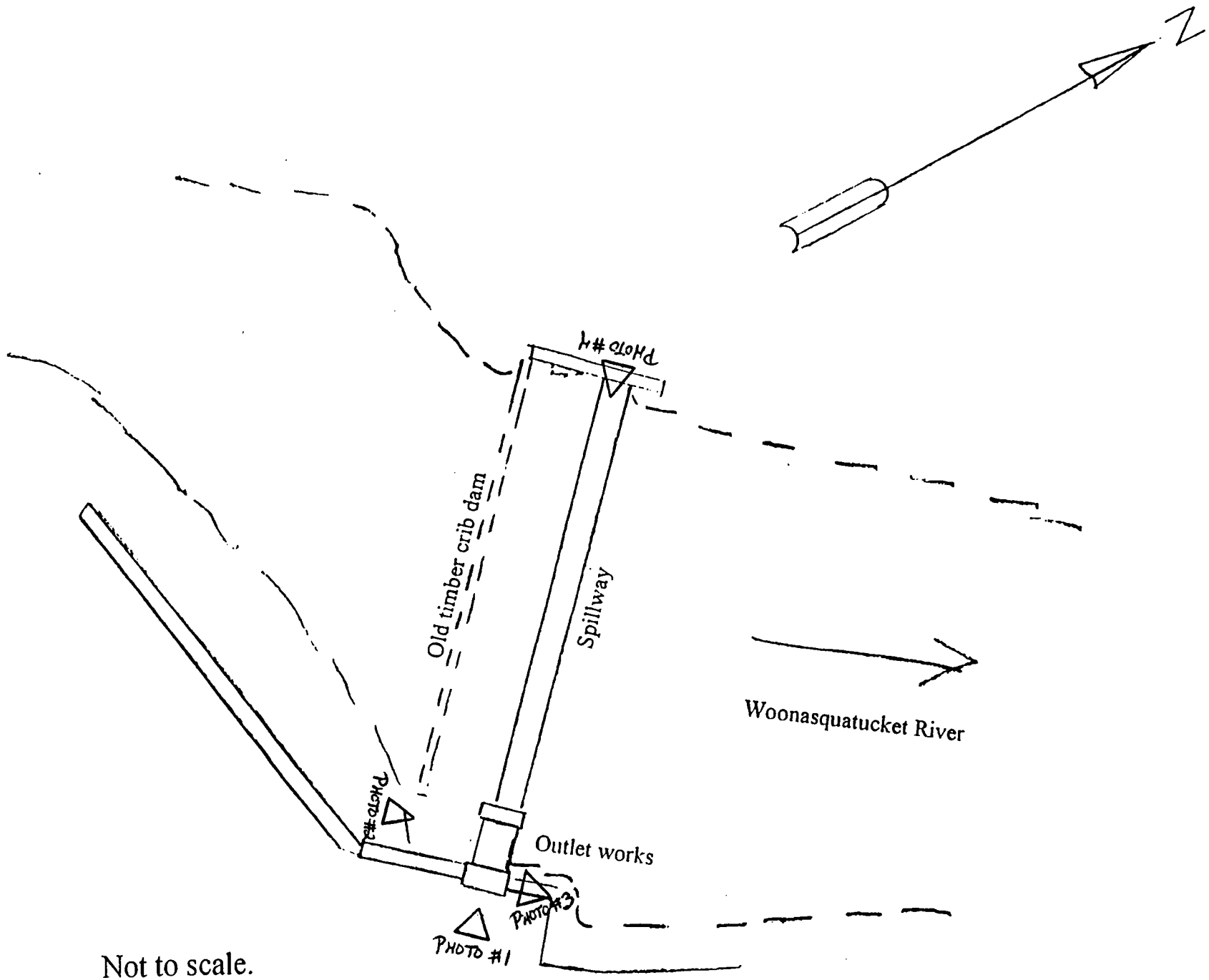
Woonasquatucket River Dams
Inspected in April 1999

Figure 1

TEAM MEMBER CHECKLIST FOR INSPECTION		
AREA EVALUATED	**BY**	**CONDITION**
CONCRETE/STRUCTURAL	**JL**	
GATE STRUCTURE		
General Condition of Concrete		Poor, with extensive spalling and concrete deterioration of the gate operator stand.
Gates		In the closed position. Functional status not determined. The two vertical timbers are weathered and cracked. Minor seepage through the gates.
Cracks		Numerous cracks with efflorescence at both the training walls, as well as at the arch portion of the gate structure.
SPILLWAY		
General Condition		Good, with minor to moderate surface abrasion at the crest.
Debris		Some branches at the top right side, otherwise, it was free of obstructions to flow.
Deterioration		Numerous areas of unsound concrete on the top surface of the left wall.
Condition of Joints		Stones at the left wall are well bonded and aligned with tight joints.
	JL	

Rising Sun Dam – Photo Locations



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RISING SUN DAM INSPECTION

Photo 1: Extensive spalling and concrete deterioration of the gate operator stand at the right side of the spillway.

Photo 2: Numerous cracks with efflorescence at the arch portion of the gate structure. *Note: the weathered and cracked vertical timbers of the gate lifting mechanism.*

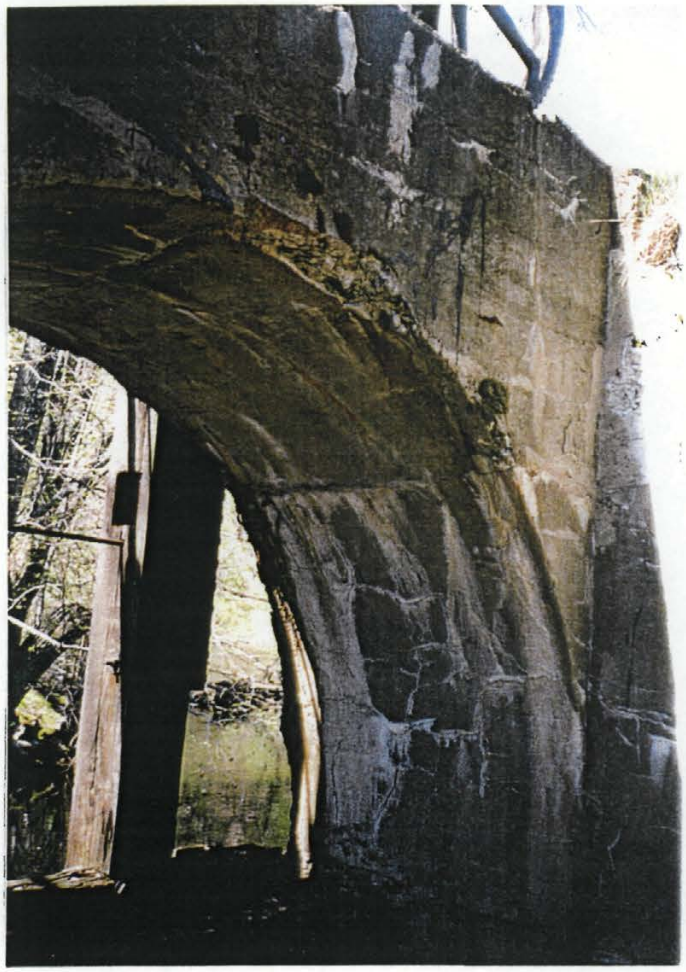
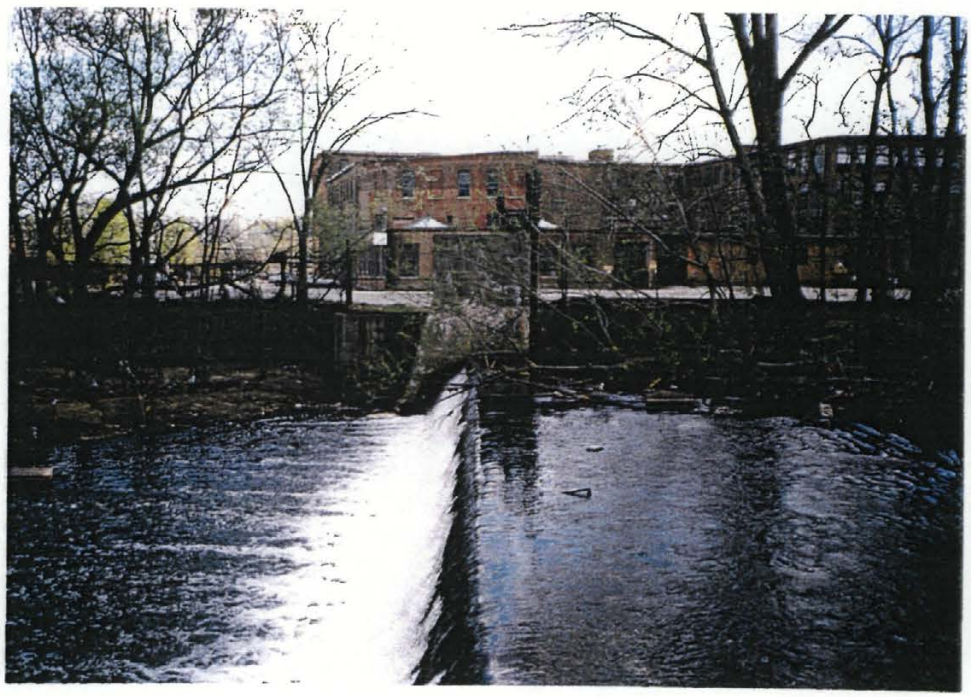


Photo 3: Numerous crack with efflorescence at the training wall of the gate structure.

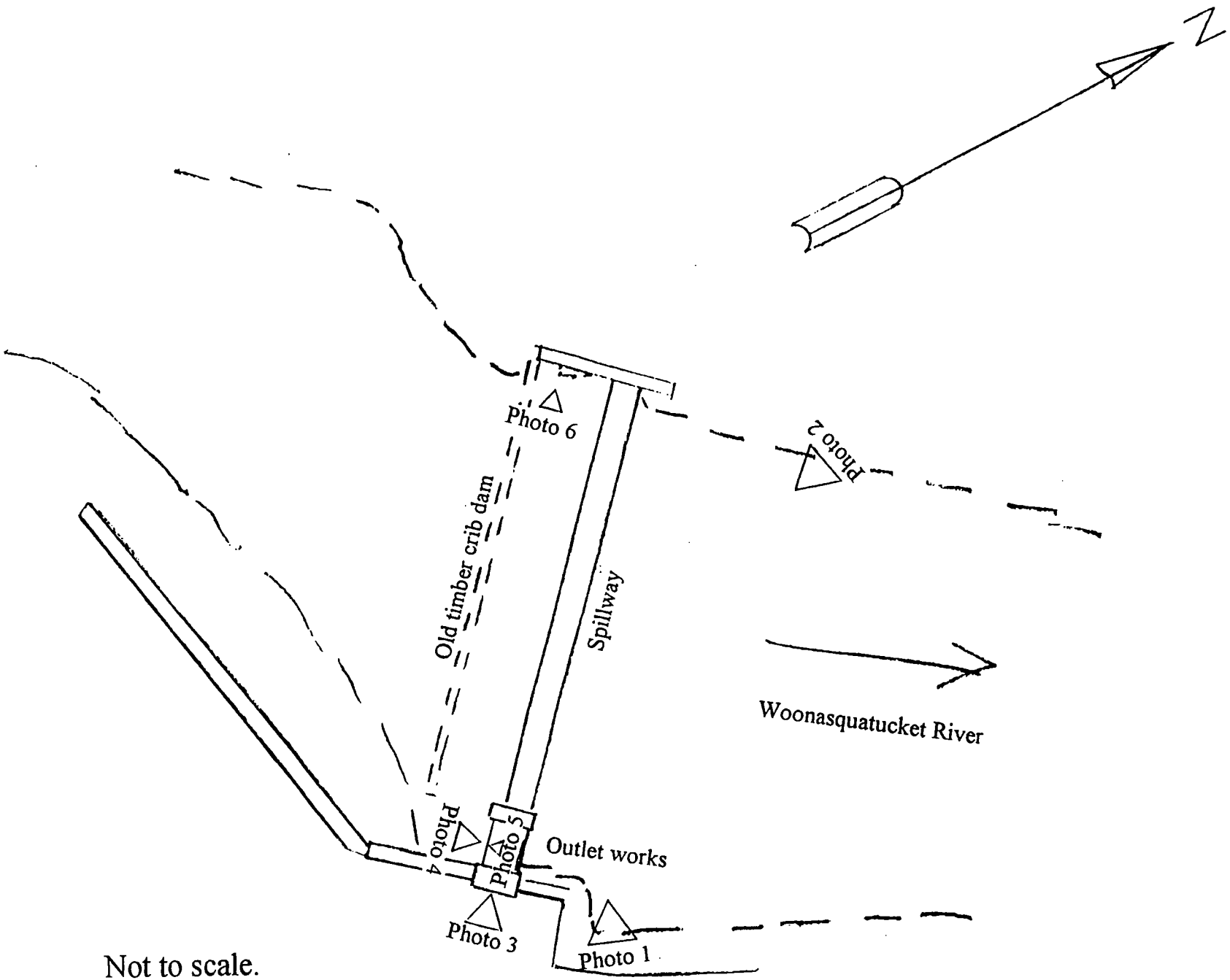
Photo 4: View of the spillway and the outlet structure. *Note: debris (branches) at the spillway on the right side.*



TEAM MEMBERS CHECK LISTS FOR INSPECTION NO. 1		
AREA EVALUATED	BY	CONDITION
GEOTECHNICAL		
ABUTMENTS		
Condition at Concrete Structures	PS	Good. No significant erosion noted. A few cracks and slight erosion in concrete walls.
Condition along right and left river banks		Fair. Trees up to 18-inch diameter and 40 foot high growing in cut stone walls.
OUTLET WORKS		
Gate		
Intake Channel		Submerged. A small amount of Debris in channel.
Outlet Channel		Clear.
Gate		Closed and inoperable.
Spillway		
Intake Channel		Submerged. Deposition within 2 feet of spillway crest. Old timber crib (original dam) partially blocks channel approximately 15 feet upstream of dam. Island of debris noted further upstream.
Outlet Channel		Depositional material and vegetation partially block right side of channel. Small amount of debris in central portion of channel.
Weir	PS	Seepage flows through cracks and holes in weir.

Team Members Check Lists for Inspection of **Rising Sun Dam**		
Area Evaluated	By	Conditions
Hydrology/Hydraulics		
Spillway	TB	Concrete.
Approach Channel		Approach channel generally clear, but an island with a large tree has formed on the right-hand side of the approach channel.
Condition		Fair to good. Only minor amounts of debris on spillway crest
Stilling Basin		None. Appears to discharge to a concrete apron, but flow prevented direct observation.
Discharge Channel		Generally clear – free of major obstructions.
Outlet Works		
Inlet		On left side of spillway.
Channel		Generally clear of obstructions.
Trash Rack		None.
Emergency Closure		None.
Gates		Wooden, closed, some leakage, appear inoperable.
Gate Passage		Inoperable.
Outlet		
Stilling Basin		None.
Exit Channel		Generally clear of obstructions.
Instrumentation		None.
Rain Gage		None.
Pool Stage Recorder		None.
Log Boom		None.

Rising Sun Dam – Photo Locations



Not to scale.

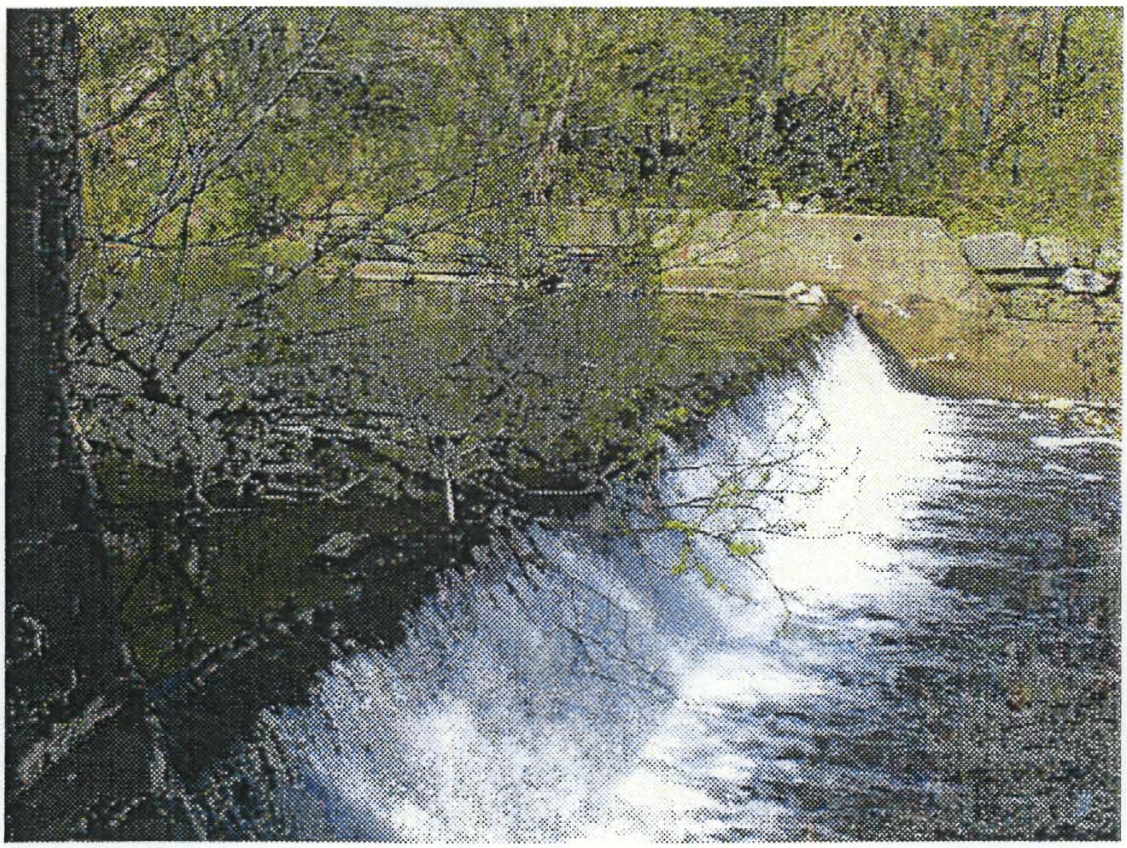


Photo 1 – Overview of dam from right bank.

Photo 2 – Overview of dam from left bank.

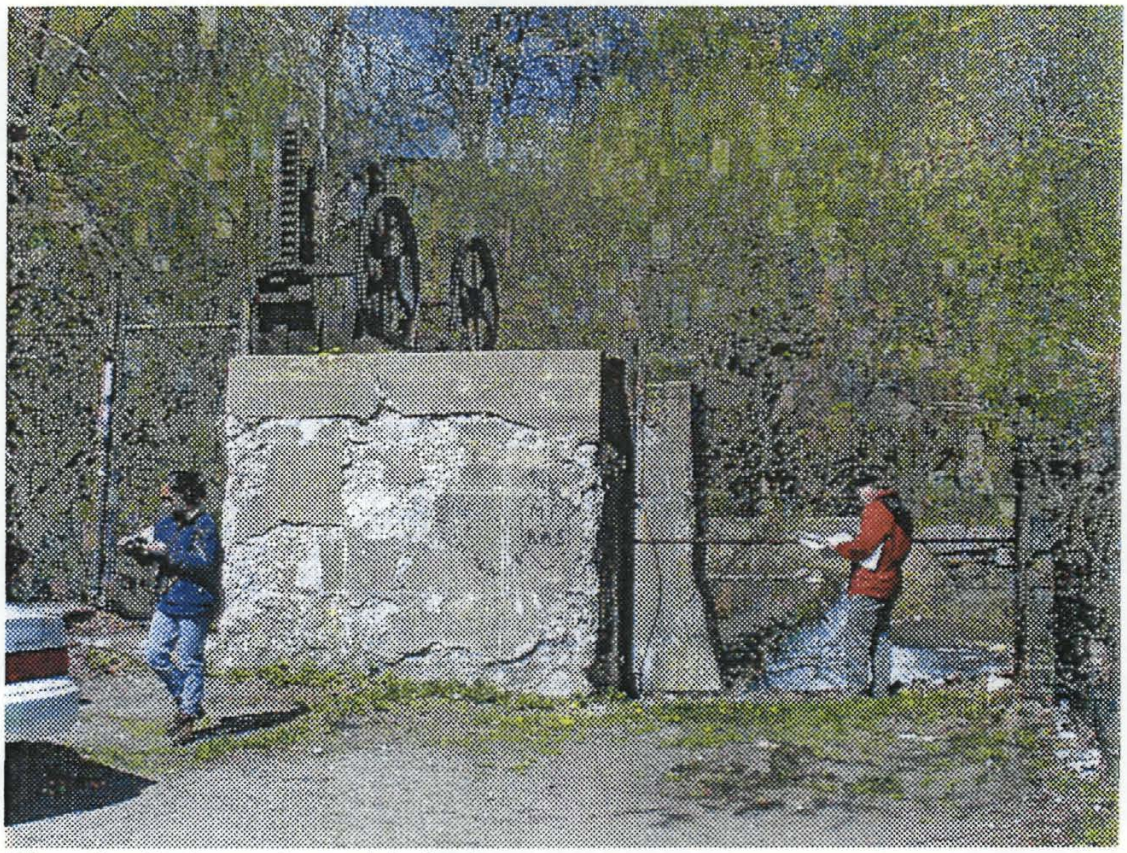


Photo 3 – Outlet works on right bank.

Photo 4 – Upstream view of outlet works on right bank.

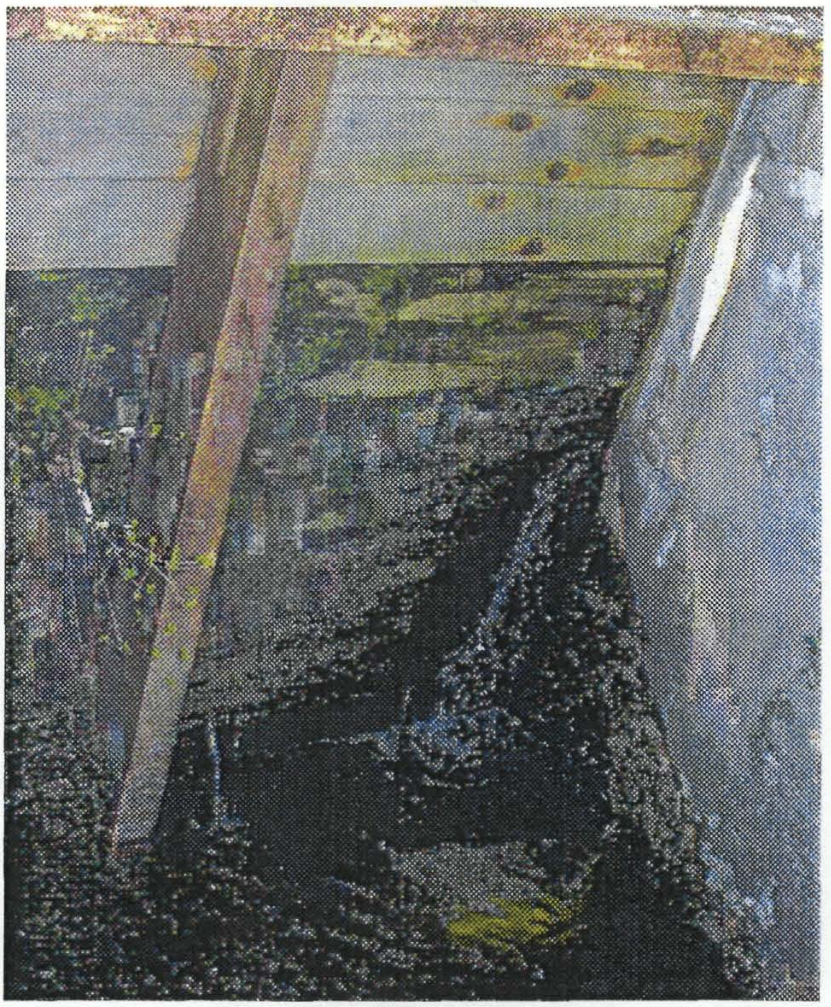


Photo 5 – Wooden gate with small amount of leakage in outlet works.

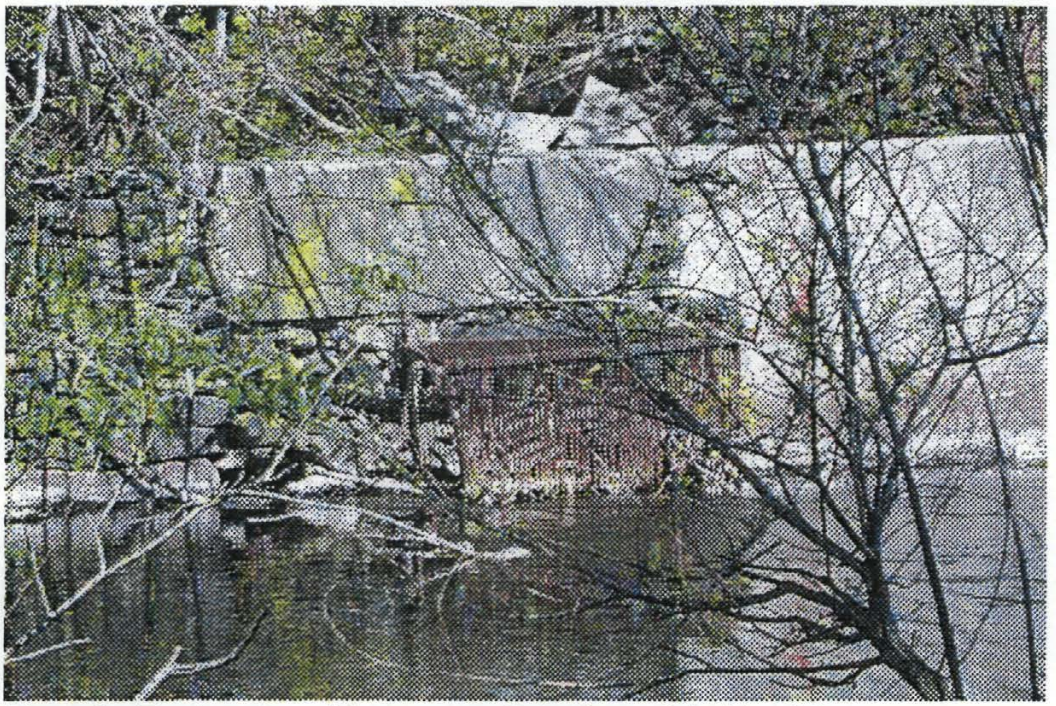


Photo 6 – Trash rack at old water supply intake on left side of dam.

RISING SUN DAM
HYDROLOGY AND HYDRAULICS ANALYSIS

1. Summary. In the absence of a significant backwater, the Rising Sun Dam's spillway capacity is 2,600 cfs, about equal to the 50-year flood. However, a backwater begins to submerge the spillway during the 15-year flood, and the dam would be overtopped by 0.7 feet during the 50-year flood. During the 100-year flood, overtopping would be 1.1 feet. Despite this overtopping, the difference in water surface elevations above and below the dam during this event would not be large—about 2.2 feet during the 100-year flood, and the dam would be unlikely to suffer a sudden catastrophic failure. The largest overtopping would be on the right abutment (looking downstream), but this area is paved and unlikely to suffer severe erosion. Overtopping of the left embankment would be less—about 0.8 feet. Although this area of exposed earth would experience more erosion than the right embankment, masonry walls would likely prevent failure of the embankment and the washout of sediments from behind the dam. Restoring the capacity of the outlet works could reduce the overtopping of the dam by half a foot.

2. Dimensions. The WPA and Donstan Corp drawings show the dam as having the following dimensions. Datum for these elevations appears to be based on arbitrarily setting the spillway to 50.0 feet, and does not appear to be equivalent to NGVD.

Elevation of top of dam – 56 ft.
Elevation of spillway crest – 50.0 ft.
Spillway width – 96 ft.
Elevation of spillway toe – 41.10 ft.
Elevation of left wingwall – 55.94 ft.
Elevation of right wingwall – 55.62 ft.
Height of dam – 15 ft.
Outlet gates – Two 4.5' wide by 9' high.

The draft report, "Hydrodynamic Modeling Site Survey, Woonasquatucket River, Providence, Rhode Island" dated December 31, 1998 for the Corps of Engineers, New England Division by Battelle, includes survey data for Rising Sun Dam. Spillway width was measured at 97.3 feet. Table 1 contains survey data from this report for stations running from the left to right abutments (looking downstream).

3. Flows. Estimated peak flood discharges at the Rising Sun Dam and water surface elevations were taken from the PFIS and are given in table 2. Tailwater elevations were plotted on probability paper, and this plot was used to interpolate the frequency of the tailwater that would reach spillway crest elevation (figure 2).

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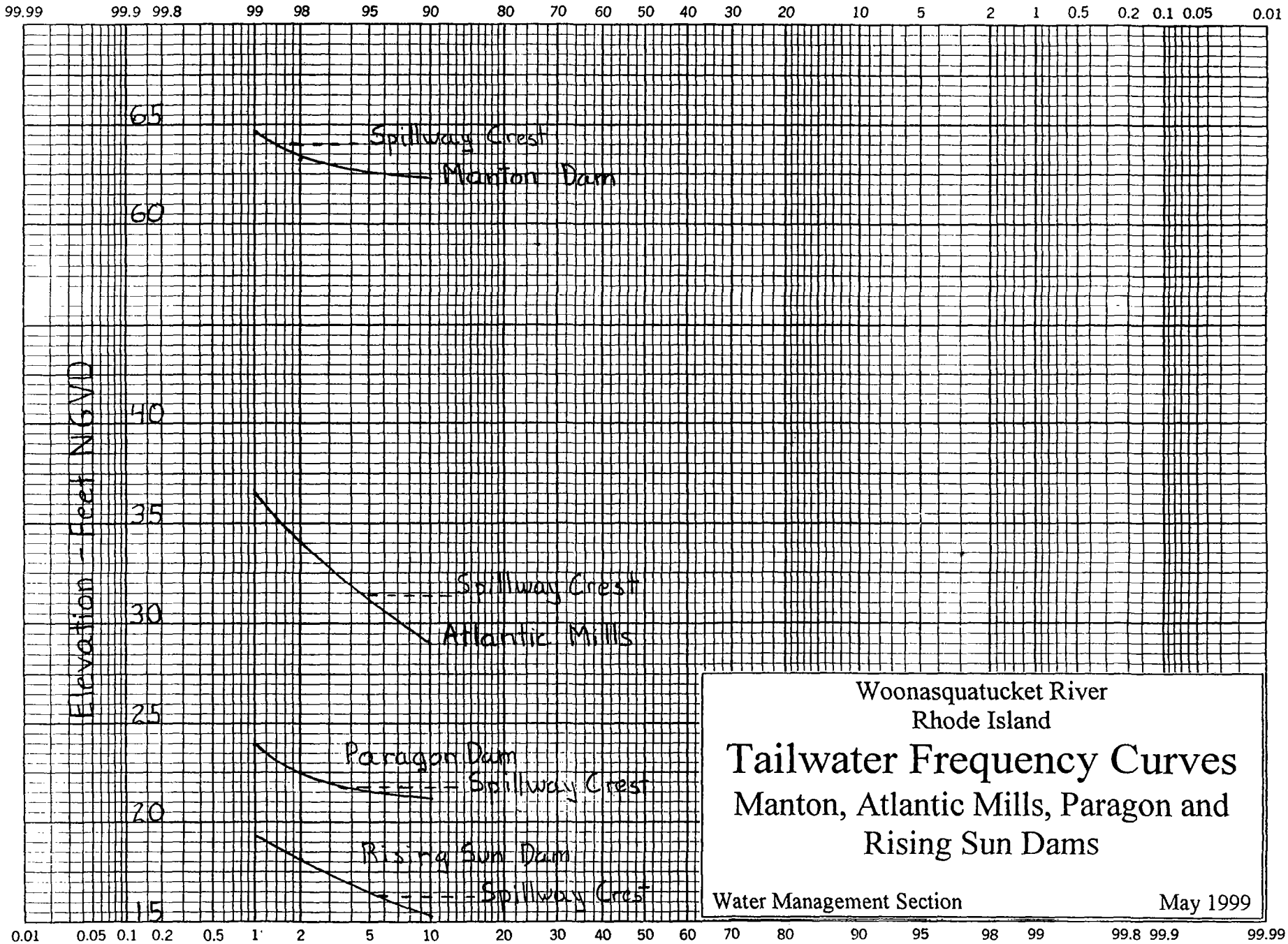

Woonasquatucket River
Rhode Island

Tailwater Frequency Curves

Manton, Atlantic Mills, Paragon and Rising Sun Dams

Water Management Section May 1999

Figure 2

TABLE 1

RISING SUN DAM
CROSS-SECTION DATA FROM BATTELLE REPORT
(All elevations are in feet and referenced to NGVD)

Station	Description	Elevation
0+00	Natural ground	27.2
0+25	Natural ground	23.2
0+50	Natural ground	21.9
0+75	Ground at toe of concrete retaining wall	20.7
0+75	Top of concrete retaining wall	22.6
0+78	Top of spillway at concrete retaining wall	16.5
0+78	Toe of spillway at concrete retaining wall	4.8
1+27	Top of spillway at centerline of dam	16.4
1+27	Toe of spillway at centerline of dam	7.7
1+72	Top of spillway at outlet works	16.4
1+72	Top of outlet works	28.8
1+72	Toe of spillway at outlet works	7.6
1+80	Toe of outlet works	20.2
1+80	Top of gate at outlet works	7.9
1+88	Ground at bituminous concrete parking	20.4
2+13	Ground at bituminous concrete parking	20.4
2+38	Ground at bituminous concrete parking	20.2
2+63	Ground at bituminous concrete parking	20.0
2+88	Ground at bituminous concrete parking	19.8
3+13	Ground at factory wall	19.5

4. Elevations. The spillway crest elevation of 16.4 was taken from survey data in the Battelle report. The top of dam elevation of 20.4 was taken from the right abutment elevation in the Battelle report. By comparison, a spillway crest elevation of 15.3 feet, NGVD was estimated from a flood profile in the PFIS; adding the 4.3-foot height of the dam from WPA drawings gave an estimated top of dam elevation of 19.6 feet.

5. Spillway Capacity. Spillway capacity was estimated using the standard weir equation. For a condition approaching a broad-crested weir with a sharply down-sloping face, a weir coefficient of 3.4 was selected. With a width of 97.3 feet, height of 4 feet, and weir coefficient of 3.4, the capacity of the spillway is 2,600 cfs assuming no backwater effects. Backwaters begin to submerge the spillway crest at about the 15-year flood. Adjustments to spillway capacity to account for effects of submergence of the crest by tailwater conditions were made using figure 5.5 of King and Brater's *Handbook of Hydraulics*. With the spillway submerged 2.9 feet during the 100-year flow from the elevation 19.3 backwater shown in the PFIS, flow over the spillway would have to be 5.1 feet deep to pass the 100-year discharge.

Table 2 Peak Discharges and Water Surface Elevations Rising Sun Dam Spillway Crest Elevation = 16.4 ft, NGVD Top of Dam Elevation = 20.4 ft, NGVD				
Event (Year)	Flow (cfs)	PFIS Water Surface Elev. Upstream of Dam (ft-NGVD)	Corps Estimated Water Surface Elev. Upstream of Dam (ft-NGVD)	PFIS Water Surface Elev. Downstream of Dam (ft-NGVD)
10	1,590	18.5		15.3
50	2,570	19.5	21.1	18.1
100	3,090	20.1	21.5	19.3

6. Comparisons. The PFIS shows the spillway crest elevation at about 15.3 feet and the 100-year water surface above the dam as about elevation 20.1 feet, NGVD. Surveys in the Battelle report show the crest more than 1 foot higher at elevation 16.4 feet. Calculations as part of this investigation based on Battelle dimensions estimate the upstream water surface elevation during the 100-year flood as 21.5 feet. The difference in water surface elevations appears to be due to the difference in spillway crest elevations.

7. Increased Discharge Capacity. Because of the large tailwater effects, restoring the outlet works capacity would reduce but not eliminate overtopping during 100-year flood levels. With the outlet works restored, the 100-year flood level upstream of the dam would be reduced from 21.5 to 21.0 feet with 630 cfs through the gate and 2,460 cfs over the spillway (not counting flow over the abutments). Overtopping of the left abutment would be reduced from 1.1 to 0.6 feet.