February 14, 1997

RECEIVED
FEB 18 1997
LMD SOLID WASTE

Mr. James R. Reyburn
Wisconsin Department of Natural Resources
1125 North Military Avenue
P.O. Box 10448
Green Bay, Wisconsin 54307-0448

Re: Results of Surface Water Modeling for the C.D. Besadny Wildlife Area, Kewaunee, Wisconsin -- STS Project No. 20716XA

Dear Jim,

Enclosed are the results of surface water modeling conducted by STS Consultants, Ltd., for the above-referenced site. Results indicate downstream arsenic concentrations in the Kewaunee River are not likely to exceed Wisconsin Administrative Code NR 105 Human Cancer Criteria Standard of 50 micrograms per liter. We would appreciate it if you would circulate this information for review and comment. Following your review, we would like to set up a meeting to discuss this project.

Please call Mike Berger at 414-468-1978 if you have any questions or comments.

Sincerely,

STS CONSULTANTS LTD.

Rodney A. Hamilton, P.E.
Project Engineer

Michael T. Berger, R.M., CHMM
Microbiologist

Mark A. Bergeon, P.G.
Associate

RAH/tjl.wd

**STS Consultants Ltd.**
Consulting Engineers

1035 Kepler Drive
Green Bay, Wisconsin 54311
414.468.1978/Fax 414.468.3312

Copy to: Mr. Thomas P. McElligott
Quarles & Brady
411 East Wisconsin Avenue
Milwaukee, Wisconsin 53202-4497

(C416A011)

*Report*

**PROJECT**

# RESULTS OF SURFACE WATER MODELING
# C.D. BESADNY WILDLIFE AREA
# KEWAUNEE, WISCONSIN

*Project No.*

20716XA

*Date*

FEBRUARY 1997

**STS Consultants Ltd.**
Consulting Engineers
1035 Kepler Drive
Green Bay, Wisconsin 54311-8320
414.468.1978/Fax 414.468.3312

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# RESULTS OF SURFACE WATER MODELING
# C.D. BESADNY WILDLIFE AREA
# KEWAUNEE, WISCONSIN
# STS PROJECT NO. 20716XA -- FEBRUARY 1997

## 1.0 INTRODUCTION

To determine potential arsenic loading into the Kewaunee River due to surface water transport, surface water modeling was conducted. In addition, results of both surface water modeling and preliminary groundwater modeling conducted by GeoTrans, Inc., were used to determine total potential arsenic loading into the Kewaunee River.

### 1.1 Surface Water Modeling

For purposes of surface water modeling, the fenced area at the site was broken into three subareas. The "Stormwater Modeling System HYDROCAD" was used to analyze the Kewaunee Marsh watersheds. This model is based on the Soil Conservation Service (SCS) Technical Release 20 Methodology and generates synthetic flood hydrographs identical to the U.S. Army Corps of Engineers HEC-1 computer model. The HYDROCAD model simulates watershed response to precipitation by representing the drainage basins as a system of interconnected hydrologic and hydraulic components. Typical input parameters to the program include basin area, overland flow travel time, soil permeability, soil infiltration relationships, land use characteristics, precipitation amounts, distribution, and base flow. See Appendix A, Figure 1 for Stormwater Runoff Model Site Map. The following table summarizes hydraulic parameters used to model surface water runoff from the site.

**TABLE 1**

HYDRAULIC PARAMETERS

| Subarea | Area (acres) | SCS Curve Number |
|---|---|---|
| 1 (north) | 6.50 | 83 |
| 2 (center) | 4.57 | 86 |
| 3 (south) | 3.10 | 83 |

See Appendix B for a summary of hydraulic parameters used in the surface water runoff model.

## 1.2 Arsenic Water Balance

A water balance was conducted using the total stormwater runoff, groundwater transport, and recorded flow in the Kewaunee River. Kewaunee River flow data were obtained from the U. S. Geological Survey (U.S.G.S.) Water Resources Investigations, Open-File Report 91-4128 Flood-Frequency Characteristics of Wisconsin Streams (see Appendix B). Groundwater transport was determined from groundwater modeling conducted by GeoTrans, Inc.

Three scenarios were used to estimate potential arsenic concentrations. In each scenario, the conservative assumption was made that all surface water runoff which comes in contact with the marsh will transport the total arsenic concentration. The three water balance scenarios included:

1. Surface water runoff concentrations equal to the maximum observed marsh surface water arsenic concentration within each subarea

2. Surface water runoff concentrations equal to the average observed marsh surface water arsenic concentrations within each subarea

3. Using a mean river water arsenic concentration as observed immediately adjacent to the site to back-calculate the potential marsh surface water arsenic concentration

The following table summarizes marsh surface water arsenic concentrations used in the three scenarios.

**TABLE 2**

ARSENIC CONCENTRATIONS

| Subarea | Sample No. | Arsenic Concentration (µg/l) |
|---|---|---|
| 1 (north) | SW03-01 (WDNR) | 360 |
| | SW05-01 (WDNR) | 76 |
| | SW06-01 (WDNR) | 60 |
| | SW07-01 (WDNR) | 110 |
| 2 (center) | Impacted area covered with compacted wood chips assume arsenic concentration | 0 (assumed) |
| 3 (south) | SW08-01 (WDNR) | 4.6 |
| | H-6 (STS) | 19,100 |
| River | River Water Sample (adjacent to site) | 3.5 |
| | Upstream Arsenic Concentration | 0 (assumed) |

Note: µg/l - micrograms per liter

The following tables summarize scenario results and calculated downstream arsenic concentrations.

**TABLE 3**

MAXIMUM ARSENIC CONCENTRATION WATER BALANCE *

| Rainfall Event Return Period (year) | Type II[1] 24-Hour Rainfall (inches) | Kewaunee River Upstream Flow (cfs) | Kewaunee River Upstream As Conc. (µg/l) | Kewaunee Marsh Surface Water Flow (cfs) | Kewaunee Marsh Surface Water As Conc. (µg/l) | Kewaunee Marsh Groundwater Flow (cfs) | Kewaunee Marsh Groundwater As Conc. (µg/l) | Kewaunee River (downstream) Flow (cfs) | Kewaunee River (downstream) As Conc. (µg/l) |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 2.4 | 2,700 | 0 | 5.6 | 4,442.3 | 0.00009 | 300,000.0 | 2,705.6 | 9.1 |
| 5 | 3.2 | 4,370 | 0 | 9.2 | 4,522.5 | 0.00009 | 300,000.0 | 4,379.2 | 9.5 |
| 10 | 3.7 | 5,490 | 0 | 11.6 | 4,554.0 | 0.00009 | 300,000.0 | 5,501.6 | 9.6 |
| 25 | 4.2 | 6,880 | 0 | 14.1 | 4,572.7 | 0.00009 | 300,000.0 | 6,894.1 | 9.3 |
| 50 | 4.7 | 7,870 | 0 | 16.6 | 4,595.5 | 0.00009 | 300,000.0 | 7,906.6 | 9.6 |
| 100 | 5.0 | 8,870 | 0 | 18.1 | 4,605.1 | 0.00009 | 300,000.0 | 8,888.1 | 9.4 |

1 - A Type II, 24-hour rainfall is a national weather service designation which represents the duration-frequency of rainfall events in the Midwest.

* See Appendix B for sample calculations.

**TABLE 4**

AVERAGE SURFACE WATER ARSENIC CONCENTRATION WATER BALANCE *

| Rainfall Event Return Period (year) | Type II 24-Hour Rainfall (inches) | Kewaunee River Upstream Flow (cfs) | Kewaunee River Upstream As Conc. (µg/l) | Kewaunee Marsh Surface Water Flow (cfs) | Kewaunee Marsh Surface Water As Conc. (µg/l) | Kewaunee Marsh Groundwater Flow (cfs) | Kewaunee Marsh Groundwater As Conc. (µg/l) | Kewaunee River (downstream) Flow (cfs) | Kewaunee River (downstream) As Conc. (µg/l) |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 2.4 | 2,700 | 0 | 5.6 | 2,210.3 | 0.00009 | 300,000.0 | 2,705.6 | 4.6 |
| 5 | 3.2 | 4,370 | 0 | 9.2 | 2,250.2 | 0.00009 | 300,000.0 | 4,379.2 | 4.7 |
| 10 | 3.7 | 5,490 | 0 | 11.6 | 2,265.8 | 0.00009 | 300,000.0 | 5,501.6 | 4.8 |
| 25 | 4.2 | 6,880 | 0 | 14.1 | 2,275.1 | 0.00009 | 300,000.0 | 6,894.1 | 4.6 |
| 50 | 4.7 | 7,870 | 0 | 16.6 | 2,286.5 | 0.00009 | 300,000.0 | 7,906.6 | 4.8 |
| 100 | 5.0 | 8,870 | 0 | 18.1 | 2,291.3 | 0.00009 | 300,000.0 | 8,888.1 | 4.7 |

* See Appendix B for sample calculations.

## TABLE 5

PROBABLE SURFACE WATER ARSENIC CONCENTRATION AS BACK-CALCULATED FROM OBSERVED RIVER WATER CONCENTRATIONS ADJACENT TO KEWAUNEE MARSH *

| Rainfall Event Return | Type II 24-Hour | Kewaunee River (downstream) | | Kewaunee Marsh Groundwater | | Kewaunee River Upstream | | Calculated Kewaunee Marsh Surface Water | |
|---|---|---|---|---|---|---|---|---|---|
| Period (year) | Rainfall (inches) | Flow (cfs) | As Conc. (μg/l) | Flow (cfs) | As Conc. (μg/l) | Flow (cfs) | As Conc. (μg/l) | Flow (cfs) | As Conc. (μg/l) |
| 2 | 2.4 | 2,705.6 | 3.5 | 0.00009 | 300,000.0 | 2,700 | 0 | 5.6 | 1,698.2 |
| 5 | 3.2 | 4,379.2 | 3.5 | 0.00009 | 300,000.0 | 4,370 | 0 | 9.2 | 1,659.4 |
| 10 | 3.7 | 5,501.6 | 3.5 | 0.00009 | 300,000.0 | 5,490 | 0 | 11.6 | 1,653.3 |
| 25 | 4.2 | 6,894.1 | 3.5 | 0.00009 | 300,000.0 | 6,880 | 0 | 14.1 | 1,710.6 |
| 50 | 4.7 | 7,906.6 | 3.5 | 0.00009 | 300,000.0 | 7,870 | 0 | 16.6 | 1,665.4 |
| 100 | 5.0 | 8,888.1 | 3.5 | 0.00009 | 300,000.0 | 8,870 | 0 | 18.1 | 1,716.2 |

* See Appendix B for sample calculations.

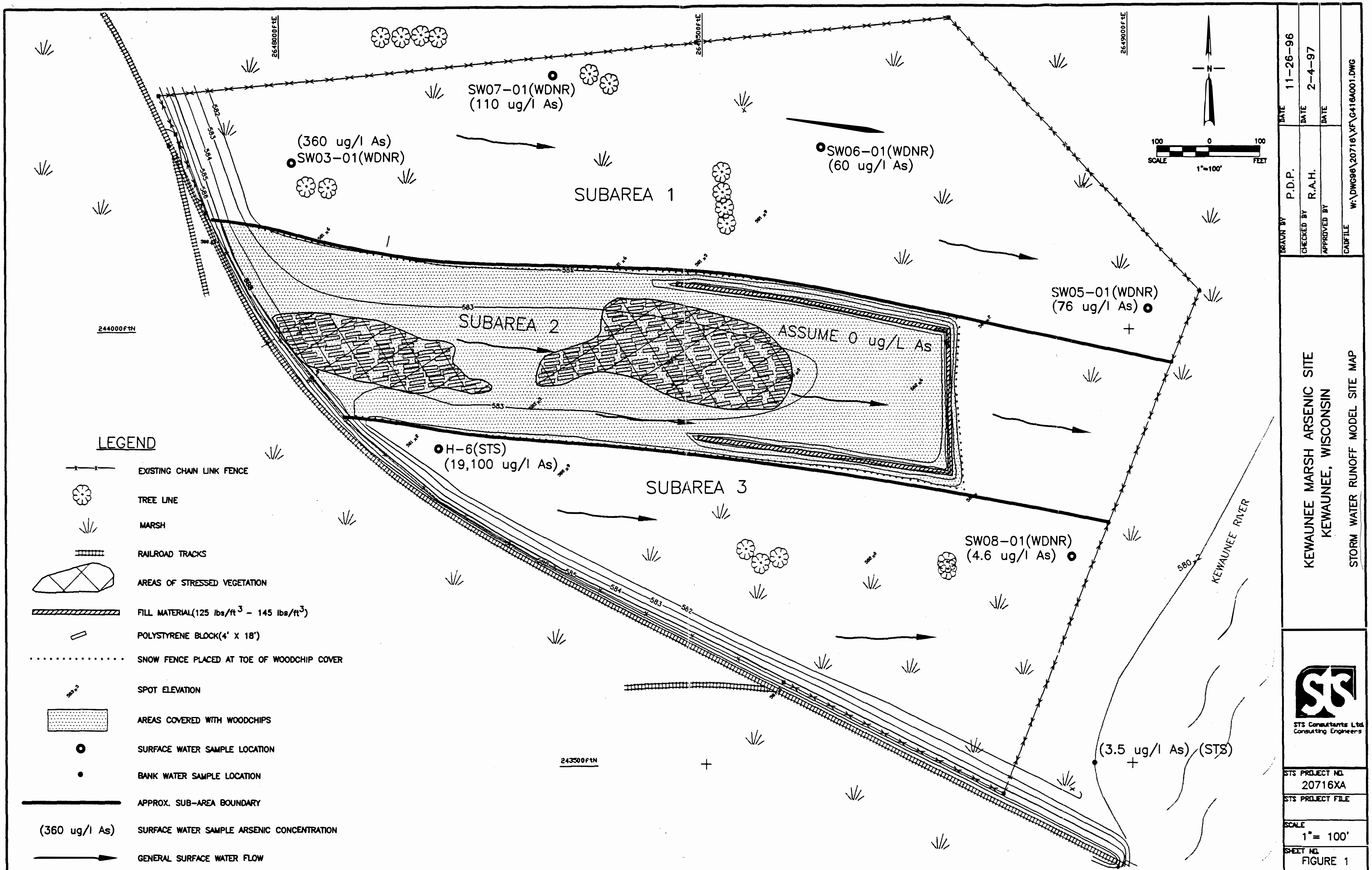
Note: See Appendix B for Kewaunee Marsh groundwater flow calculations and spreadsheet calculations used to develop Tables 3, 4, and 5.

## 2.0 CONCLUSIONS

Based on average marsh arsenic concentrations from surface water data and modeled maximum arsenic groundwater discharge concentrations, the potential maximum downstream arsenic concentration in the Kewaunee River was calculated to be 4.8 µg/l. Based on maximum marsh arsenic concentrations from surface water data and modeled maximum arsenic groundwater discharge concentrations, the potential maximum downstream arsenic concentration in the Kewaunee River was calculated to be 9.6 µg/L. Both calculated concentrations are comparable to concentrations measured in water samples collected from the Kewaunee River adjacent to the site. Calculated concentrations are below the Wisconsin Administrative Code NR 105 Human Cancer Criteria Standard of 50 µg/L. Results of hydraulic modeling indicate that arsenic transported to the Kewaunee River should not exceed surface water standards.

# APPENDIX A

Stormwater Runoff Model Site Map



SW07-01(WDNR)
(110 ug/l As)
(360 ug/l As)
SW03-01(WDNR)
SW06-01(WDNR)
(60 ug/l As)
SUBAREA 1
SUBAREA 2
ASSUME 0 ug/L As
SW05-01(WDNR)
(76 ug/l As)
H-6(STS)
(19,100 ug/l As)
SUBAREA 3
SW08-01(WDNR)
(4.6 ug/l As)
(3.5 ug/l As) (STS)
KEWAUNEE RIVER
2648000ftE
2648500ftE
2649000ftE
244000ftN
243500ftN
SCALE 1"=100' FEET
N
LEGEND
EXISTING CHAIN LINK FENCE
TREE LINE
MARSH
RAILROAD TRACKS
AREAS OF STRESSED VEGETATION
FILL MATERIAL(125 lbs/ft³ - 145 lbs/ft³)
POLYSTYRENE BLOCK(4' X 18')
SNOW FENCE PLACED AT TOE OF WOODCHIP COVER
SPOT ELEVATION
AREAS COVERED WITH WOODCHIPS
SURFACE WATER SAMPLE LOCATION
BANK WATER SAMPLE LOCATION
APPROX. SUB-AREA BOUNDARY
(360 ug/l As) SURFACE WATER SAMPLE ARSENIC CONCENTRATION
GENERAL SURFACE WATER FLOW
DRAWN BY P.D.P. DATE 11-26-96
CHECKED BY R.A.H. DATE 2-4-97
APPROVED BY DATE
CADFILE W:\DWG96\20716\XF\G416A001.DWG
KEWAUNEE MARSH ARSENIC SITE
KEWAUNEE, WISCONSIN
STORM WATER RUNOFF MODEL SITE MAP
STS Consultants Ltd. Consulting Engineers
STS PROJECT NO. 20716XA
STS PROJECT FILE
SCALE 1"= 100'
SHEET NO. FIGURE 1

# APPENDIX B

Flow Calculation Spreadsheets

Hydraulic Parameters

Kewaunee River Flow Data

Groundwater Discharge Data

Arsenic Concentrations

Sample Calculations

GeoTrans, Inc., Preliminary Results of Groundwater Modeling

## Water Balance Using Maximum Observed Surface Water Arsenic Concentrations From Marsh

| Kewaunee Marsh Flow Calculations | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Volume (acre-feet) | | | | Volume (gallons) | | | Peak Discharge (cfs) | | | | |
| Storm (yr) | Area 1 | Area 2 | Area 3 | | Area 1 | Area 2 | Area 3 | Area 1 | Area 2 | Area 3 | Total | |
| 2 | 0.47 | 0.39 | 0.22 | | 153,144 | 127,077 | 71,684 | 2.29 | 2.02 | 1.25 | 5.56 | |
| 5 | 0.77 | 0.62 | 0.37 | | 250,895 | 202,020 | 120,560 | 3.88 | 3.23 | 2.11 | 9.22 | |
| 10 | 0.98 | 0.77 | 0.47 | | 319,321 | 250,895 | 153,144 | 4.93 | 4.02 | 2.68 | 11.63 | |
| 25 | 1.19 | 0.93 | 0.57 | | 387,747 | 303,029 | 185,728 | 6.01 | 4.82 | 3.26 | 14.09 | |
| 50 | 1.4 | 1.08 | 0.67 | | 456,173 | 351,905 | 218,311 | 7.11 | 5.63 | 3.86 | 16.60 | |
| 100 | 1.53 | 1.17 | 0.73 | | 498,532 | 381,230 | 237,862 | 7.77 | 6.12 | 4.22 | 18.11 | |

Summary

| Rainfall Event (year) | | Kewaunee River (down stream) Flow (cfs) | As Conc. (ug/l) |
|---|---|---|---|
| 2 | | 2,705.6 | 9.1 |
| 5 | | 4,379.2 | 9.5 |
| 10 | | 5,501.6 | 9.6 |
| 25 | | 6,894.1 | 9.3 |
| 50 | | 7,906.6 | 9.6 |
| 100 | | 8,888.1 | 9.4 |

| Maximum Surface Water As Conc (ug/l) | | | | As Conc Flowing from Marsh (ug/l) | | |
|---|---|---|---|---|---|---|
| Area 1 | Area 2 | Area 3 | | | | |
| 360 | 0 | 19,100 | | | 4,442.3 | |
| 360 | 0 | 19,100 | | | 4,522.5 | |
| 360 | 0 | 19,100 | | | 4,554.0 | |
| 360 | 0 | 19,100 | | | 4,572.7 | |
| 360 | 0 | 19,100 | | | 4,595.5 | |
| 360 | 0 | 19,100 | | | 4,605.1 | |

Water Balance Using Maximum Observed Surface Water Arsenic Concentrations From Marsh

| Rainfall Event (year) | Kewaunee River Upstream Flow (cfs) | Kewaunee River Upstream As Conc. (ug/l) | Kewaunee Marsh Flow (cfs) | Kewaunee Marsh As Conc. (ug/l) | Kewaunee Marsh Ground Water Flow (cfs) | Kewaunee Marsh Ground Water As. Conc. (ug/l) | Kewaunee River (down stream) Flow (cfs) | Kewaunee River (down stream) As Conc. (ug/l) |
|---|---|---|---|---|---|---|---|---|
| 2 | 2,700 | 0 | 5.6 | 4,442.3 | 0.00009 | 300,000 | 2,705.6 | 9.1 |
| 5 | 4,370 | 0 | 9.2 | 4,522.5 | 0.00009 | 300,000 | 4,379.2 | 9.5 |
| 10 | 5,490 | 0 | 11.6 | 4,554.0 | 0.00009 | 300,000 | 5,501.6 | 9.6 |
| 25 | 6,880 | 0 | 14.1 | 4,572.7 | 0.00009 | 300,000 | 6,894.1 | 9.3 |
| 50 | 7,890 | 0 | 16.6 | 4,595.5 | 0.00009 | 300,000 | 7,906.6 | 9.6 |
| 100 | 8,870 | 0 | 18.1 | 4,605.1 | 0.00009 | 300,000 | 8,888.1 | 9.4 |

Kewaunee Marsh Flow Calculations

| | Volume (acre-feet) | | | Volume (gallons) | | | Peak Discharge (cfs) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Storm (yr) | Area 1 | Area 2 | Area 3 | Area 1 | Area 2 | Area 3 | Area 1 | Area 2 | Area 3 | Total |
| 2 | 0.47 | 0.39 | 0.22 | 153,144 | 127,077 | 71,684 | 2.29 | 2.02 | 1.25 | 5.56 |
| 5 | 0.77 | 0.62 | 0.37 | 250,895 | 202,020 | 120,560 | 3.88 | 3.23 | 2.11 | 9.22 |
| 10 | 0.98 | 0.77 | 0.47 | 319,321 | 250,895 | 153,144 | 4.93 | 4.02 | 2.68 | 11.63 |
| 25 | 1.19 | 0.93 | 0.57 | 387,747 | 303,029 | 185,728 | 6.01 | 4.82 | 3.26 | 14.09 |
| 50 | 1.4 | 1.08 | 0.67 | 456,173 | 351,905 | 218,311 | 7.11 | 5.63 | 3.86 | 16.60 |
| 100 | 1.53 | 1.17 | 0.73 | 498,532 | 381,230 | 237,862 | 7.77 | 6.12 | 4.22 | 18.11 |

Summary

| Rainfall Event | Kewaunee River (down stream) | |
|---|---|---|
| (years) | Flow (cfs) | As Conc. (ug/l) |
| 2 | 2,705.6 | 4.6 |
| 5 | 4,379.2 | 4.7 |
| 10 | 5,501.6 | 4.8 |
| 25 | 6,894.1 | 4.6 |
| 50 | 7,906.6 | 4.8 |
| 100 | 8,888.1 | 4.7 |

# Water Balance Using Average Observed Surface Water Arsenic Concentrations In Marsh

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Average Surface Water As Conc | | | | As Conc Flowing from Marsh | | | | | | | | | |
| (ug/l) | | | | | (ug/l) | | | | | | | | |
| Area 1 | Area 2 | Area 3 | | | | | | | | | | | |
| 152 | 0 | 9,553 | | | 2,210.3 | | | | | | | | |
| 152 | 0 | 9,553 | | | 2,250.2 | | | | | | | | |
| 152 | 0 | 9,553 | | | 2,265.8 | | | | | | | | |
| 152 | 0 | 9,553 | | | 2,275.1 | | | | | | | | |
| 152 | 0 | 9,553 | | | 2,286.5 | | | | | | | | |
| 152 | 0 | 9,553 | | | 2,291.3 | | | | | | | | |

Water Balance Using Average Observed Surface Water Arsenic Concentrations in Marsh

| Rainfall Event | Kewaunee River Upstream | | Kewaunee Marsh | | Kewaunee Marsh Ground Water | | Kewaunee River (down stream) | |
|---|---|---|---|---|---|---|---|---|
| (years) | Flow (cfs) | As Conc. (ug/l) | Flow (cfs) | As Conc. (ug/l) | Flow (cfs) | As. Conc. (ug/l) | Flow (cfs) | As Conc. (ug/l) |
| 2 | 2,700 | 0 | 5.6 | 2,210.3 | 0.00009 | 300,000 | 2,705.6 | 4.6 |
| 5 | 4,370 | 0 | 9.2 | 2,250.2 | 0.00009 | 300,000 | 4,379.2 | 4.7 |
| 10 | 5,490 | 0 | 11.6 | 2,265.8 | 0.00009 | 300,000 | 5,501.6 | 4.8 |
| 25 | 6,880 | 0 | 14.1 | 2,275.1 | 0.00009 | 300,000 | 6,894.1 | 4.6 |
| 50 | 7,890 | 0 | 16.6 | 2,286.5 | 0.00009 | 300,000 | 7,906.6 | 4.8 |
| 100 | 8,870 | 0 | 18.1 | 2,291.3 | 0.00009 | 300,000 | 8,888.1 | 4.7 |

Water Balance Using Observed River Water Arsenic Concentration To Back Calculate Probable Surface Water Arsenic Concentration In Marsh

| Kewaunee Marsh Flow Calculations | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Volume (acre-feet) | | | | Volume (gallons) | | | | Peak Discharge (cfs) | | | |
| Storm (yr) | Area 1 | Area 2 | Area 3 | | Area 1 | Area 2 | Area 3 | | Area 1 | Area 2 | Area 3 | Total |
| 2 | 0.47 | 0.39 | 0.22 | | 153,144 | 127,077 | 71,684 | | 2.29 | 2.02 | 1.25 | 5.56 |
| 5 | 0.77 | 0.62 | 0.37 | | 250,895 | 202,020 | 120,560 | | 3.88 | 3.23 | 2.11 | 9.22 |
| 10 | 0.98 | 0.77 | 0.47 | | 319,321 | 250,895 | 153,144 | | 4.93 | 4.02 | 2.68 | 11.63 |
| 25 | 1.19 | 0.93 | 0.57 | | 387,747 | 303,029 | 185,728 | | 6.01 | 4.82 | 3.26 | 14.09 |
| 50 | 1.4 | 1.08 | 0.67 | | 456,173 | 351,905 | 218,311 | | 7.11 | 5.63 | 3.86 | 16.60 |
| 100 | 1.53 | 1.17 | 0.73 | | 498,532 | 381,230 | 237,862 | | 7.77 | 6.12 | 4.22 | 18.11 |

Summary

| Rainfall Event | | Kewaunee Marsh Concentration | |
|---|---|---|---|
| (year) | | Flow | Ar Conc. |
| | | (cfs) | (ug/l) |
| 2 | | 5.6 | 1698.2 |
| 5 | | 9.2 | 1659.4 |
| 10 | | 11.6 | 1653.3 |
| 25 | | 14.1 | 1710.6 |
| 50 | | 16.6 | 1665.4 |
| 100 | | 18.1 | 1716.2 |

| | Average Surface Water As Conc (ug/l) | | | | As Conc Flowing from Marsh (ug/l) | | |
|---|---|---|---|---|---|---|---|
| | Area 1 | Area 2 | Area 3 | | | | |
| | 152 | 0 | 9,553 | | | 2,210.3 | |
| | 152 | 0 | 9,553 | | | 2,250.2 | |
| | 152 | 0 | 9,553 | | | 2,265.8 | |
| | 152 | 0 | 9,553 | | | 2,275.1 | |
| | 152 | 0 | 9,553 | | | 2,286.5 | |
| | 152 | 0 | 9,553 | | | 2,291.3 | |

Water Balance Using Observed River Water Arsenic Concentration To Back Calculate Probable Surface Water Arsenic Concentration In Marsh

| | | | | | Kewaunee Marsh | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainfall Event | | Kewaunee River (down stream) | | | Ground Water | | | Kewaunee River Upstream | | | Kewaunee Marsh | |
| (year) | | Flow | As Conc. | | Flow | As Conc. | | Flow | As Conc. | | Flow | As Conc. |
| | | (cfs) | (ug/l) | | (cfs) | (ug/l) | | (cfs) | (ug/l) | | (cfs) | (ug/l) |
| 2 | | 2,705.6 | 3.5 | | 0.00009 | 300,000 | | 2,700 | 0 | | 5.6 | 1,698.2 |
| 5 | | 4,379.2 | 3.5 | | 0.00009 | 300,000 | | 4,370 | 0 | | 9.2 | 1,659.4 |
| 10 | | 5,501.6 | 3.5 | | 0.00009 | 300,000 | | 5,490 | 0 | | 11.6 | 1,653.3 |
| 25 | | 6,894.1 | 3.5 | | 0.00009 | 300,000 | | 6,880 | 0 | | 14.1 | 1,710.6 |
| 50 | | 7,906.6 | 3.5 | | 0.00009 | 300,000 | | 7,890 | 0 | | 16.6 | 1,665.4 |
| 100 | | 8,888.1 | 3.5 | | 0.00009 | 300,000 | | 8,870 | 0 | | 18.1 | 1,716.2 |

STS Consultants Ltd.
CALCULATION SHEET

| PROJECT | STS JOB NO. |
|---|---|
| KEWAUNEE MARSH | |
| SUBJECT: HYDRAULIC PARAMETERS | SHEET NO. OF |

| ORIGINATED BY | DATE | CHECKED BY | DATE | CALC. NO. | REV. NO. |
|---|---|---|---|---|---|
| RAH | 12/9/96 | | | | |

| SUBAREA | AREA | SCS CURVE NUMBER | LENGTH | SLOPE |
|---|---|---|---|---|
| 1 (NORTH) | 6.50 AC | 83 ① | 1060' | 0.001 FT/FT |
| 2 (CENTRAL) | 4.57 AC | 86 ② | $L_1$ = 780'<br>$L_2$ = 225' | $S_1$ = 0.001 FT/FT<br>$S_2$ = 0.001 FT/FT |
| 3 (SOUTH) | 3.10 AC | 83 ① | 860' | S = 0.001 FT/FT |

① BRUSH/GRASS MIXTURE - POOR CURVE NUMBER = 83

② 79% OF AREA COMPACTED WOODCHIPS (CN = 87)
21% OF AREA BRUSH/GRASS MIXTURE (CN = 83)

PRECIP. VALUES FROM SCS TR-55

| RETURN PERIOD (YR) | TYPE II 24-HOUR RAINFALL (INCHES) |
|---|---|
| 2 | 2.4 |
| 5 | 3.2 |
| 10 | 3.7 |
| 25 | 4.2 |
| 50 | 4.7 |
| 100 | 5.0 |

**Table 4.** *Flood discharges at selected recurrence intervals and WRC skew for gaging stations in Wisconsin*--Continued

| Station number | Station name | WRC skew | Discharge for indicated recurrence interval — Years 2 | 5 | 10 | 25 | 50 | 100 | $SE_{100}$ | Remarks[1] |
|---|---|---|---|---|---|---|---|---|---|---|
| 04075200 | Evergreen Creek near Langlade, Wis. | 0.046 | 44.5 | 56.2 | 63.5 | 72.5 | 78.9 | 85.3 | 10.1 | |
| 04075500 | Wolf River above West Branch Wolf River near Keshena, Wis. | .318 | 1,740 | 2,120 | 2,360 | 2,665 | 2,890 | 3,120 | 8.7 | |
| 04077000 | Wolf River at Keshena Falls near Keshena, Wis. | .356 | 2,410 | 3,070 | 3,520 | 4,100 | 4,545 | 5,000 | 7.5 | |
| 04078500 | Embarrass River near Embarrass, Wis. | -.070 | 2,340 | 3,460 | 4,235 | 5,240 | 6,000 | 6,780 | 10.8 | |
| 04079000 | Wolf River at New London, Wis. | -.224 | 6,720 | 9,460 | 11,200 | 13,400 | 14,900 | 16,400 | 9.1 | |
| 04079700 | Spaulding Creek near Big Falls, Wis. | .109 | 52.5 | 67.7 | 77.6 | 90.0 | 99.2 | 108 | 11.2 | |
| 04080000 | Little Wolf River at Royalton, Wis. | -.522 | 3,195 | 4,850 | 5,880 | 7,095 | 7,930 | 8,715 | 10.7 | |
| 04081000 | Waupaca River near Waupaca, Wis. | -.518 | 1,060 | 1,540 | 1,835 | 2,175 | 2,405 | 2,620 | 9.9 | |
| 04081010 | Waupaca River tributary near Waupaca, Wis. | -.499 | 41.4 | 69.8 | 89.1 | 113 | 130 | 147 | 22.5 | |
| 04081900 | Sawyer Creek at Oshkosh, Wis. | -.001 | 427 | 861 | 1,240 | 1,840 | 2,370 | 2,970 | 31.7 | |
| | | -.243 | 542 | 1,020 | 1,400 | 1,930 | 2,360 | 2,810 | 25.1 | G |
| 04083000 | West Branch Fond du Lac River at Fond du Lac, Wis. | -.700 | 760 | 1,140 | 1,370 | 1,620 | 1,780 | 1,930 | 20.1 | |
| 04083400 | East Branch Fond du Lac River tributary near Eden, Wis. | -.416 | 57.6 | 96.6 | 123 | 158 | 183 | 207 | 23.1 | |
| 04083500 | East Branch Fond du Lac River at Fond du Lac, Wis. | -.710 | 908 | 1,550 | 1,960 | 2,440 | 2,760 | 3,060 | 26.5 | |
| 04084500 | Fox River at Rapide Croche Dam, near Wrightstown, Wis. | -.768 | 12,700 | 17,000 | 19,200 | 21,600 | 23,000 | 24,200 | 6.7 | E |
| 04085030 | Apple Creek near Kaukauna, Wis. | -.735 | 787 | 1,210 | 1,460 | 1,730 | 1,910 | 2,070 | 15.6 | |
| 04085100 | East River tributary at Greenleaf, Wis. | -.162 | 216 | 379 | 504 | 678 | 818 | 965 | 25.8 | |
| 04085200 | Kewaunee River near Kewaunee, Wis. | -.417 | 2,700 | 4,370 | 5,490 | 6,880 | 7,890 | 8,870 | 17.6 | |
| 04085281 | East Twin River at Mishicot, Wis. | -.163 | 1,200 | 2,020 | 2,620 | 3,440 | 4,080 | 4,750 | 29.5 | |
| 04085300 | Neshota River tributary near Denmark, Wis. | -.424 | 193 | 326 | 418 | 536 | 622 | 707 | 19.6 | |
| 04085400 | Killsnake River near Chilton, Wis. | -.606 | 627 | 1,060 | 1,340 | 1,680 | 1,910 | 2,130 | 19.6 | |
| 04085427 | Manitowoc River at Manitowoc, Wis. | -.154 | 2,590 | 4,270 | 5,510 | 7,170 | 8,470 | 9,820 | 27.7 | |
| 04085700 | Sheboygan River tributary near Plymouth, Wis. | -.032 | 113 | 183 | 235 | 307 | 365 | 426 | 24.4 | |
| 04086000 | Sheboygan River at Sheboygan, Wis. | -.655 | 3,140 | 5,000 | 6,150 | 7,480 | 8,380 | 9,200 | 13.6 | |
| 04086150 | Milwaukee River at Kewaskum, Wis. | -.059 | 900 | 1,460 | 1,860 | 2,420 | 2,870 | 3,330 | 29.4 | |
| 04086200 | East Branch Milwaukee River near New Fane, Wis. | -.137 | 214 | 352 | 455 | 593 | 702 | 815 | 31.1 | |
| 04086340 | North Branch Milwaukee River near Fillmore, Wis. | -.266 | 789 | 1,380 | 1,820 | 2,420 | 2,880 | 3,360 | 33.5 | |
| 04086360 | Milwaukee River at Waubeka, Wis. | -.391 | 2,110 | 3,530 | 4,520 | 5,770 | 6,710 | 7,630 | 28.6 | |
| 04086400 | Milwaukee River tributary near Fredonia, Wis. | -.586 | 55.0 | 105 | 141 | 188 | 221 | 254 | 30.0 | |
| 04086500 | Cedar Creek near Cedarburg, Wis. | -.189 | 951 | 1,860 | 2,600 | 3,670 | 4,570 | 5,530 | 20.1 | |
| 04087000 | Milwaukee River at Milwaukee, Wis. | -.057 | 4,890 | 6,990 | 8,580 | 10,700 | 12,300 | 13,900 | 10.4 | |
| 04087030 | Menomonee River at Menomonee Falls, Wis. | .160 | 539 | 788 | 968 | 1,210 | 1,400 | 1,610 | 27.3 | |
| 04087050 | Little Menomonee River near Freistadt, Wis. | -.446 | 182 | 272 | 328 | 395 | 441 | 485 | 14.5 | |
| 04087088 | Underwood Creek at Wauwatosa, Wis. | -.298 | 857 | 1,430 | 1,840 | 2,370 | 2,780 | 3,180 | 34.8 | |
| 04087100 | Honey Creek at Milwaukee, Wis. | -.035 | 319 | 488 | 609 | 769 | 894 | 1,020 | 17.7 | |
| 04087120 | Menomonee River at Wauwatosa, Wis. | .023 | 3,400 | 5,670 | 7,430 | 9,920 | 12,000 | 14,100 | 23.1 | |
| 04087200 | Oak Creek near South Milwaukee, Wis. | -.117 | 258 | 453 | 604 | 817 | 989 | 1,170 | 22.5 | |
| 04087204 | Oak Creek at South Milwaukee, Wis. | .113 | 585 | 767 | 887 | 1,040 | 1,150 | 1,260 | 13.1 | |
| 04087220 | Root River near Franklin, Wis. | .219 | 1,080 | 1,860 | 2,500 | 3,470 | 4,310 | 5,250 | 27.3 | |
| 04087230 | West Branch Root River Canal tributary near North Cape, Wis. | -.603 | 89.4 | 133 | 160 | 190 | 210 | 228 | 15.2 | |
| 04087233 | Root River Canal near Franklin, Wis. | -.274 | 709 | 975 | 1,140 | 1,340 | 1,480 | 1,810 | 13.5 | |
| 04087240 | Root River at Racine, Wis. | -.032 | 1,940 | 2,760 | 3,300 | 4,000 | 4,530 | 5,070 | 16.0 | |
| 04087250 | Pike Creek near Kenosha, Wis. | -.308 | 82.6 | 135 | 171 | 217 | 252 | 287 | 19.0 | |
| 04087257 | Pike River near Racine, Wis. | -.453 | 878 | 1,180 | 1,350 | 1,540 | 1,670 | 1,790 | 16.8 | |
| 05332500 | Namekagon River near Trego, Wis. | .573 | 1,170 | 1,620 | 1,960 | 2,440 | 2,830 | 3,260 | 12.8 | E |
| 05333100 | Little Frog Creek near Minong, Wis. | -.345 | 205 | 378 | 508 | 685 | 823 | 964 | 24.2 | |

STS Consultants Ltd.
CALCULATION SHEET

| PROJECT | | | | STS JOB NO. | |
|---|---|---|---|---|---|
| KEWAUNEE MARSH | | | | | |
| SUBJECT | | | | SHEET NO. OF | |
| GROUND WATER DISCHARE | | | | | |
| ORIGINATED BY | DATE | CHECKED BY | DATE | CALC. NO. | REV. NO. |
| | | | | | |

FROM JAMES ERICKSON - GEOTRANS, INC.

DARCY VELOCITY ≈ 0.15 ft/yr (AVERAGE VELOCITY OVER CROSS SECTIONAL AREA)

$$= \left(0.15 \frac{FT}{yr}\right)\left(\frac{1\,yr}{365\,days}\right)\left(\frac{1\,day}{24\,hrs}\right)\left(\frac{1\,hr}{60\,min}\right)\left(\frac{1\,min}{60\,sec}\right)$$

$$= 4.756 \times 10^{-9} \text{ FT/SEC.}$$

DARCY VELOCITY × CROSS-SECTIONAL AREA = TOTAL Q

LENGTH OF SITE ALONG RIVER = 960 FEET
DEPTH OF RIVER = 20 FEET

$$\therefore Q_{CFS} = 4.756 \times 10^{-9} \frac{FT}{SEC} \times (960\,FT)(20\,FT)$$

$$= 0.000091315 \text{ CFS}$$

$$Q = 9.1315 \times 10^{-5} \text{ CFS}$$

| STS Consultants Ltd. CALCULATION SHEET | PROJECT: C.D. BESADNY WILDLIFE AREA | | | STS JOB NO.: 20716XA | |
|---|---|---|---|---|---|
| | SUBJECT: SURFACE WATER As. | | | SHEET NO. 1 OF 1 | |
| | ORIGINATED BY: RAH | DATE: 12/6/96 | CHECKED BY: | DATE: | CALC. NO.: | REV. NO.: |

| | SAMPLE NO. | CONCENTRATION (ug/l) | |
|---|---|---|---|
| SUBAREA 1 (NORTH) | SW03-01 (WDNR) | 360 → MAXIMUM | AVERAGE = 152 ug/l |
| | SW05-01 (WDNR) | 76 | |
| | SW06-01 (WDNR) | 60 | |
| | SW07-01 (WDNR) | 110 | |

SUBAREA 2 (CENTRAL)

FOR WATER BALANCE SUBAREA As CONCENTRATION HAS BEEN ASSUMED 0 ug/l FOR SURFACE WATER

| | SAMPLE NO. | CONCENTRATION (ug/l) | |
|---|---|---|---|
| SUBAREA 3 (SOUTH) | SW08-01 (WDNR) | 4.6 | |
| | H-6 (STS) | 19,100 → MAXIMUM | AVERAGE = 9,553 ug/l |

KEWAUNEE RIVER BANK WATER IMMEDIATELY DOWN STREAM OF MARSH → THE As VALUE USED IS THE AVERAGE OF SAMPLES COLLECTED ON 8/12/96 & 10/23/96

- DOWN STREAM As = 3.5 ug/l
- UPSTREAM As = 0 ug/l (ASSUMED)

| STS Consultants Ltd. CALCULATION SHEET | PROJECT: C.D. BESADNY WILDLIFE AREA | | | | STS JOB NO.: 20716XA | |
|---|---|---|---|---|---|---|
| | SUBJECT: SAMPLE CALCULATIONS | | | | SHEET NO.: 1 OF | |
| | ORIGINATED BY: RAH | DATE: 2/13/97 | CHECKED BY: | DATE: | CALC. NO.: | REV. NO.: |

SAMPLE CALCULATIONS FOR ESTIMATING ARSENIC CONCENTRATIONS OF SURFACE WATER FLOWING FROM THE MARSH.

- FIRST TABLE IN APPENDIX B 2 YEAR STORM MAX. As CONCENTRATIONS

$$\frac{\left[\left(\text{AREA 1 FLOW} \times \text{AREA 1 As CONC. (MAX)}\right) + \left(\text{AREA 2 FLOW} \times \text{AREA 2 As CONC. (MAX)}\right) + \left(\text{AREA 3 FLOW} \times \text{AREA 3 As CONC. (MAX)}\right)\right]}{\text{TOTAL FLOW FROM MARSH}} = \text{As CONC. FLOWING FROM MARSH (MAX)}$$

$$\frac{\left[(2.29 \text{ cfs} \times 360 \text{ ug/l}) + (2.02 \text{ cfs} \times 0 \text{ ug/l}) + (1.25 \text{ cfs} \times 19{,}100 \text{ ug/l})\right]}{5.56 \text{ cfs}} = 4{,}442.3 \text{ ug/l}$$

- SECOND TABLE IN APPENDIX B 2 YEAR STORM AVERAGE As CONCENTRATIONS

$$\frac{\left[\left(\text{AREA 1 FLOW} \times \text{AREA 1 As CONC. (AVE)}\right) + \left(\text{AREA 2 FLOW} \times \text{AREA 2 As CONC. (AVE)}\right) + \left(\text{AREA 3 FLOW} \times \text{AREA 3 As CONC. (AVE)}\right)\right]}{\text{TOTAL FLOW FROM MARSH}} = \text{As CONC. FLOWING FROM MARSH (AVE)}$$

$$\frac{\left[(2.29 \text{ cfs} \times 152 \text{ ug/l}) + (2.02 \text{ cfs} \times 0 \text{ ug/l}) + (1.25 \text{ cfs} \times 9{,}553 \text{ ug/l})\right]}{5.56 \text{ cfs}} = 2{,}210.3 \text{ ug/l}$$

NOTE: As CONCENTRATIONS IN SURFACE WATER DISCHARGE INCREASES AS FLOW INCREASE BECAUSE THE INCREASE OF SURFACE WATER FLOW FROM EACH SUBAREA IS NOT PROPORTIONAL AS THE YEAR OF THE EVENT STORM INCREASES

STS Consultants Ltd.
CALCULATION SHEET

| PROJECT | | | | STS JOB NO. | |
|---|---|---|---|---|---|
| C.D. BESADNY WILDLIFE AREA | | | | 20716XA | |
| SUBJECT | | | | SHEET NO. | |
| SAMPLE CALCULATIONS | | | | 1 OF 1 | |
| ORIGINATED BY | DATE | CHECKED BY | DATE | CALC. NO. | REV. NO. |
| RAH | 12/17/97 | | | | |

THESE SAMPLE CALCULATION ARE USED TO DEVELOP TABLES 3 AND 4

EXAMPLE CALCULATION USES DATA FROM TABLE 3 AND A FIVE YEAR STORM EVENT

(1)
$$\frac{\left[(\text{KEWAUNEE RIVER UPSTREAM FLOW} \times \text{As CONC.}) + (\text{KEWAUNEE MARSH SURFACE WATER FLOW} \times \text{As CONC.}) + (\text{KEWAUNEE MARSH GROUNDWATER FLOW} \times \text{As CONC.})\right]}{\text{KEWAUNEE RIVER DOWN STREAM FLOW}} = \text{KEWAUNEE RIVER DOWN STREAM As CONC.}$$

(2)
$$\frac{\left[(4{,}370\text{ cfs} \times 0\ \text{ug/l}) + (9.2\text{ cfs} \times 4{,}522.5\ \text{ug/l}) + (0.00009\text{ cfs} \times 300{,}000\ \text{ug/l})\right]}{4{,}379.2\text{ cfs}} = 9.5\ \text{ug/l}$$

(3) KEWAUNE RIVER DOWN STREAM FLOW = KEWAUNEE RIVER UPSTREAM FLOW + KEWAUNEE MARSH SURFALE WATER FLOW + KEWAUNEE MARSH GROUND WATER FLOW

| STS Consultants Ltd. CALCULATION SHEET | PROJECT: C.D. BESADNY WILDLIFE AREA | | | STS JOB NO.: 20716XA | |
|---|---|---|---|---|---|
| | SUBJECT: SAMPLE CALCULATIONS | | | SHEET NO. 1 OF 1 | |
| | ORIGINATED BY: RAH | DATE: 12/17/97 | CHECKED BY: | DATE: | CALC. NO.: | REV. NO.: |

SAMPLE CALCULATION FOR DEVELOPING TABLE 5

EXAMPLE CALCULATION USES DATA FROM TABLE 5 AND A FIVE YEAR STORM EVENT.

$$\frac{\left[\left(\text{KEWAUNEE RIVER DOWN STREAM FLOW} \times \text{As CONC.}\right) + \left(\text{KEWAUNEE MARSH GROUND WATER FLOW} \times \text{As CONC.}\right) + \left(\text{KEWAUNEE RIVER UPSTREAM FLOW} \times \text{As CONC.}\right)\right]}{\text{KEWAUNEE MARSH SURFACE WATER FLOW}} = \text{CALCULATED KEWAUNEE MARSH As. CONC.}$$

$$\frac{\left[\left(4{,}379.2 \text{ cfs} \times 3.5 \text{ ug/l}\right) + \left(0.00009 \text{ cfs} \times 300{,}000 \text{ ug/l}\right) + \left(4{,}370 \text{ cfs} \times 0 \text{ ug/l}\right)\right]}{9.2 \text{ cfs}} = 1{,}659.4 \text{ ug/l}$$

November 11, 1996

Mr. James R. Reyburn
Wisconsin Department of Natural Resources
1125 North Military Avenue
P.O. Box 10448
Green Bay, Wisconsin 54307-0448

Re: Preliminary Results of Groundwater Modeling for the C.D. Besadny Arsenic Site, Kewaunee, Wisconsin -- STS Project No. 20716XA

Dear Jim,

Enclosed are the preliminary results of groundwater modeling. We will also be providing you with preliminary surface water modeling results shortly. We would appreciate it if you would circulate this information for review and comment. Following your review, we would like to arrange a meeting to discuss this information.

If you have any questions or comments regarding this project, please contact me at 406-3210. We appreciate your assistance with this project.

Sincerely,

STS CONSULTANTS LTD.

Michael T. Berger, R.M., CHMM
Microbiologist

Mark A. Bergeon, P.G.
Associate

MTB/dke.wd

Enclosures:
GeoTrans, Inc., Preliminary Modeling Results

Copy to: Mr. Thomas P. McElligott
Quarles & Brady
411 East Wisconsin Avenue
Milwaukee, Wisconsin 53202-4497

(C416A010)

**STS Consultants Ltd.**
Consulting Engineers

1035 Kepler Drive
Green Bay, Wisconsin 54311-8320
414.468.1978/Fax 414.468.3312

GeoTrans, inc.
GROUNDWATER SPECIALISTS

4888 Pearl East Circle ▪ Suite 300-E ▪ Boulder, Colorado ▪ 80301

303 ▪ 440 ▪ 4556 303 ▪ 440 ▪ 4863 FAX

October 10, 1996

Mr. Michael T. Berger
STS Consultants Ltd.
1035 Kepler Drive
Green Bay, Wisconsin 54311

Dear Mike:

Enclosed are preliminary results from the Kewaunee Marsh arsenic transport modeling work. Figures 1 through 3 are potentiometric surface maps for the site based on State water level measurements. Figure 4 is the best fit of measured sediment/water arsenic concentrations to the Freundlich and Langmuir isotherms.

Figures 5 through 12 show the results of the BIO1D model simulations. Figures 5 and 6 show the flow paths used in the BIO1D model simulations. The flow paths are based on flow lines from the potentiometric surface map for May 1996. Figure 6 shows the combined STS and State groundwater arsenic concentration data and the one-dimensional grids used to extrapolate initial concentration data for the start of the model simulations.

Figure 7 shows the initial concentration data used in the model simulations for the Central Flow Path. Figure 8 shows the arsenic concentration distribution from the upgradient end of the Central Flow Path to the Kewaunee River after 8000 years. Figure 9 shows the concentration breakthrough at the Kewaunee River as a function of time. The maximum concentration discharge to the river is about 300 mg/L after about 2700 years.

Figures 10 through 12 show the transport results for the Northern Flow Path. Figure 10 is the initial starting concentration data for the model simulations. Figure 11 shows the distribution of arsenic concentration in the groundwater after 3000 years and Figure 12 shows the concentration breakthrough at the river as a function of time.

All model simulation were run with the Langmuir isotherm, which is the more conservative of the two isotherms. We plan to perform a sensitivity analysis of the model for both the Freundlich and Langmuir isotherms to demonstrate that the results are not significantly impacted by the choice of isotherms.

I would like to discuss future model runs that STS and State would like to see performed for the Kewaunee Marsh site. Please call me after you have had a chance to review these results.

Sincerely,

James R. Erickson
Principal Hydrogeologist
Boulder Office Manager

Enclosures

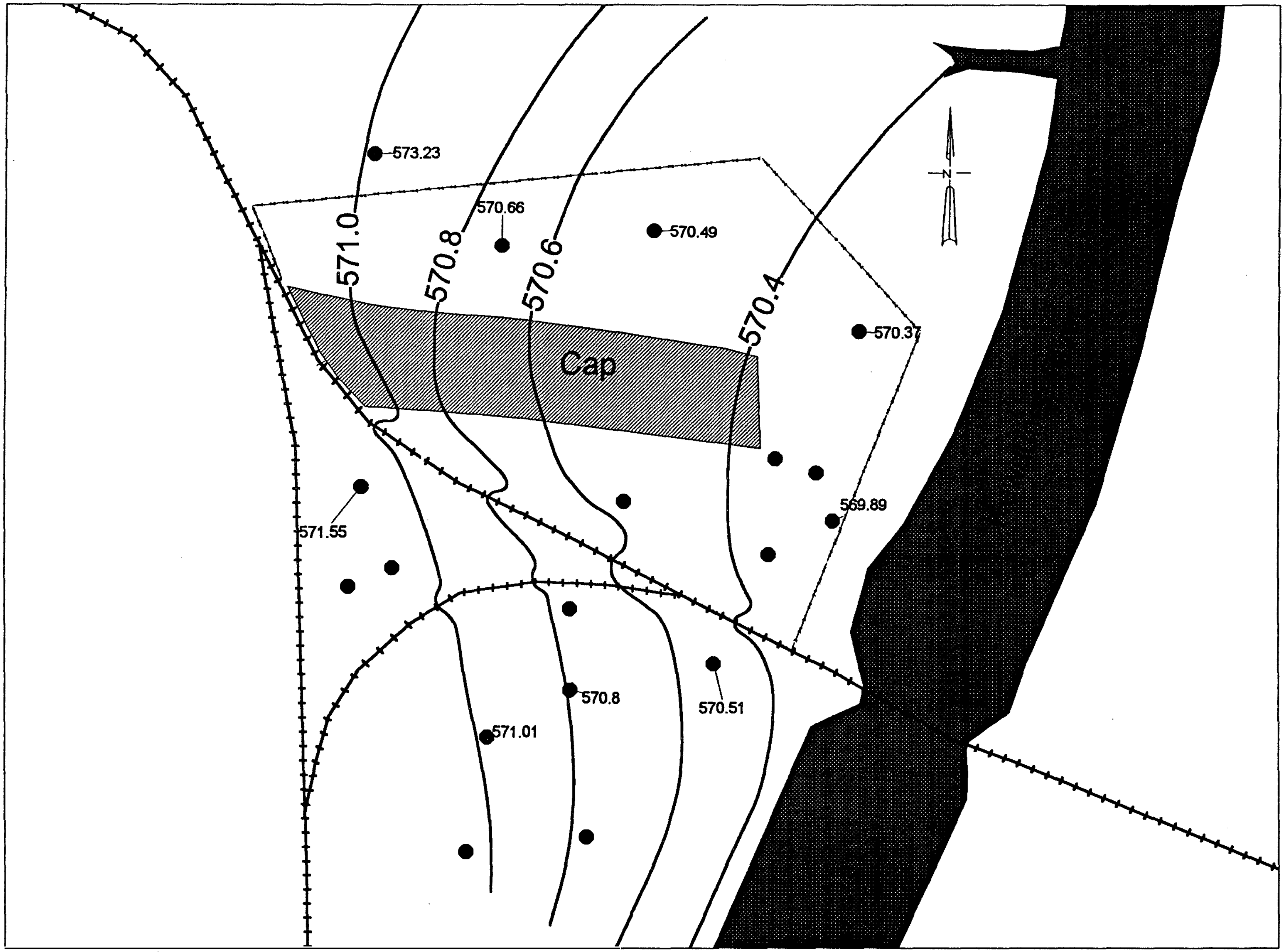



Figure 1. Potentiometric surface based on State water-level measurements at the Kewaunee marsh for May 1996.

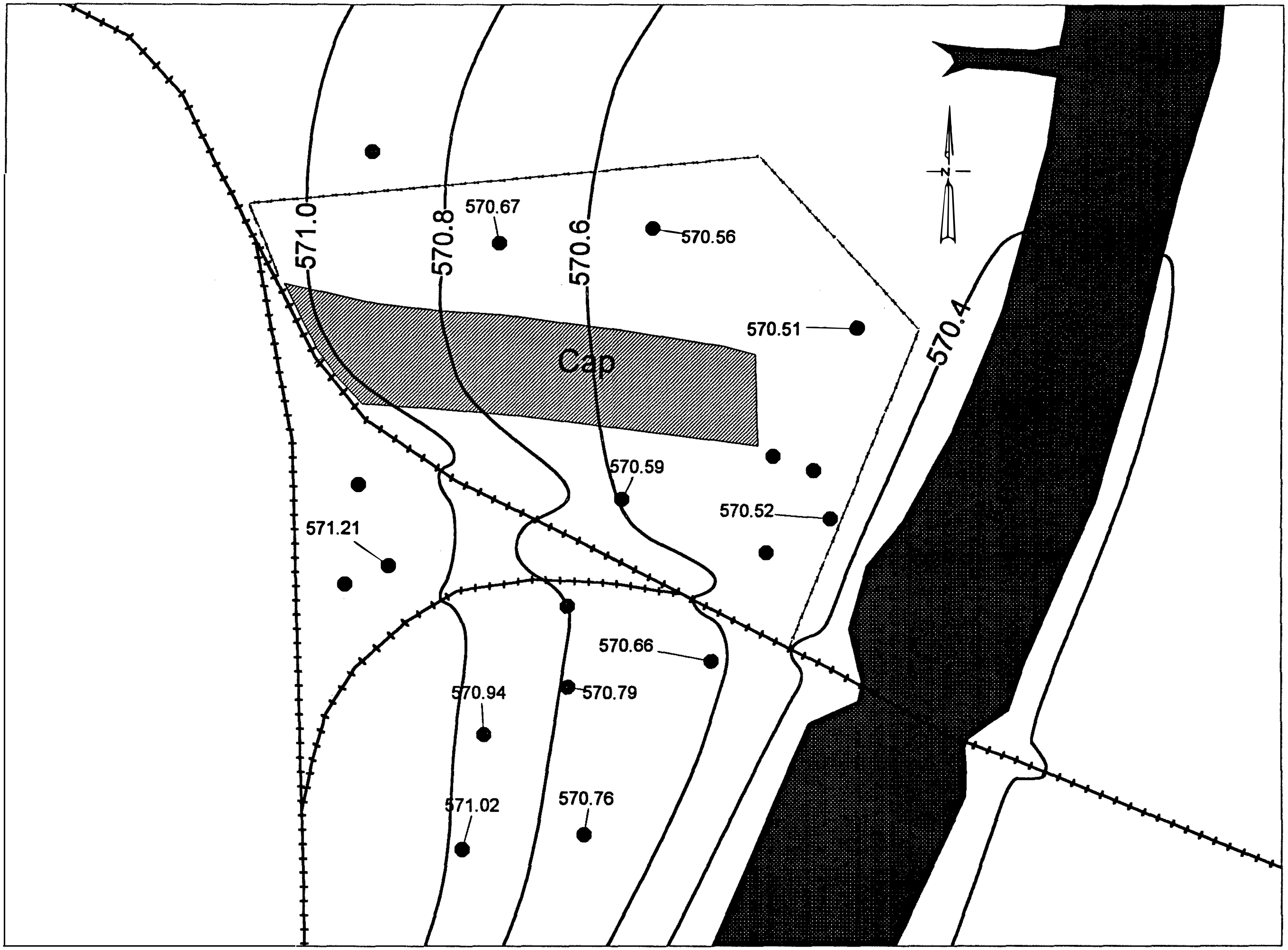



Figure 2. Potentiometric surface based on State water-level measurements at the Kewaunee marsh for August 1996.

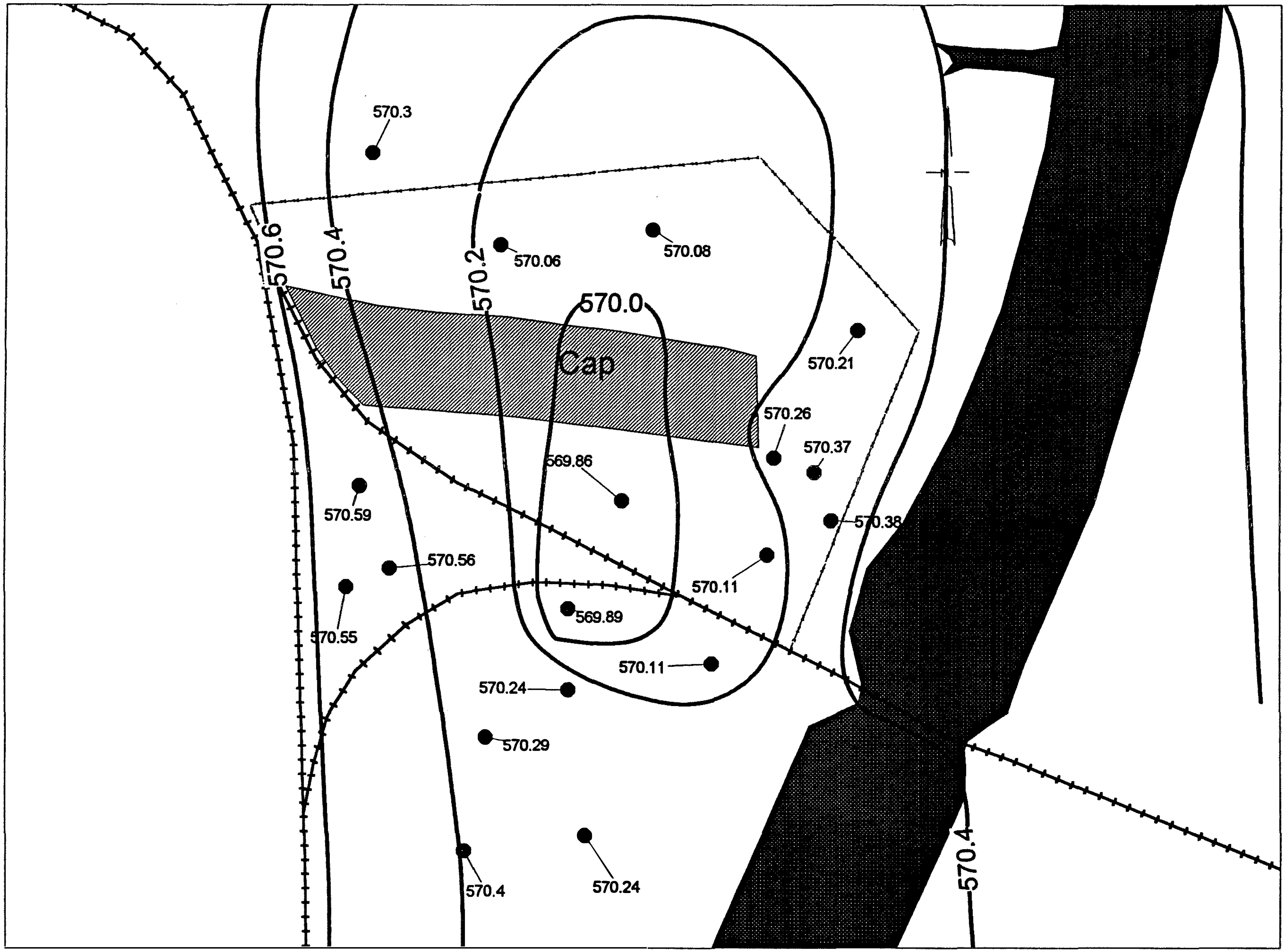



Figure 3. Potentiometric surface based on State water-level measurements at the Kewaunee marsh for September 1996.

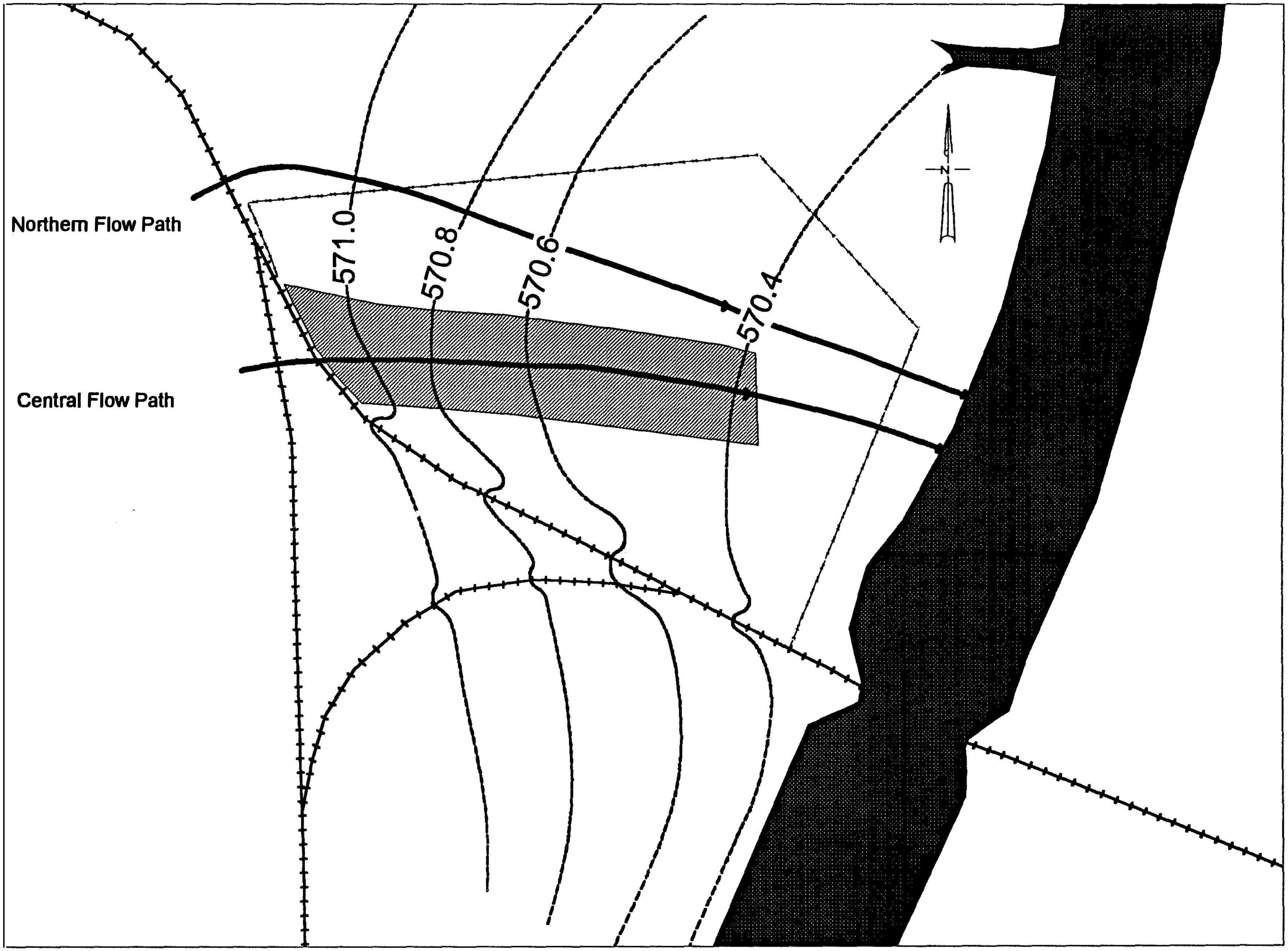



Figure 5. BIO1D flow paths for arsenic transport simulations .

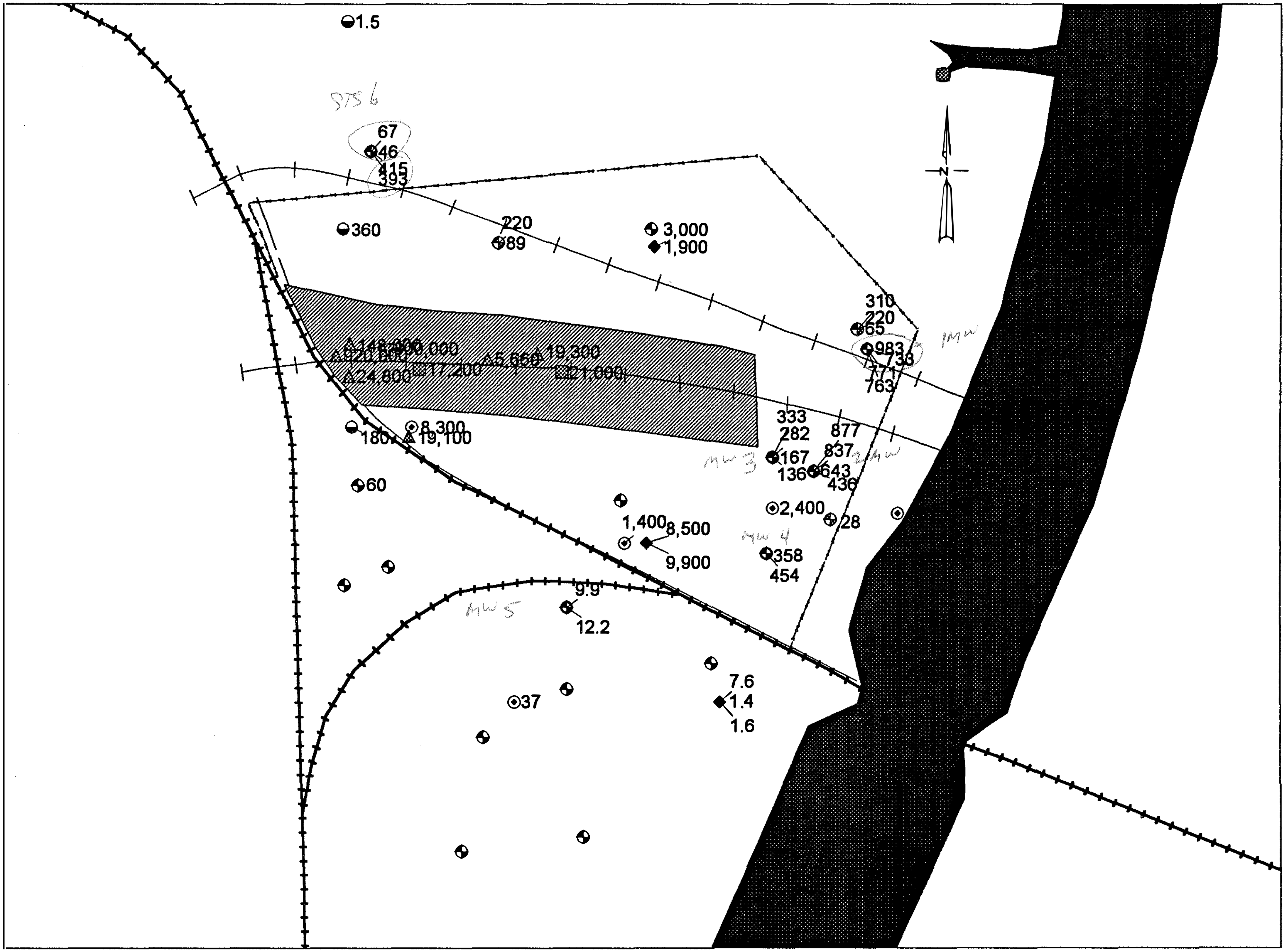
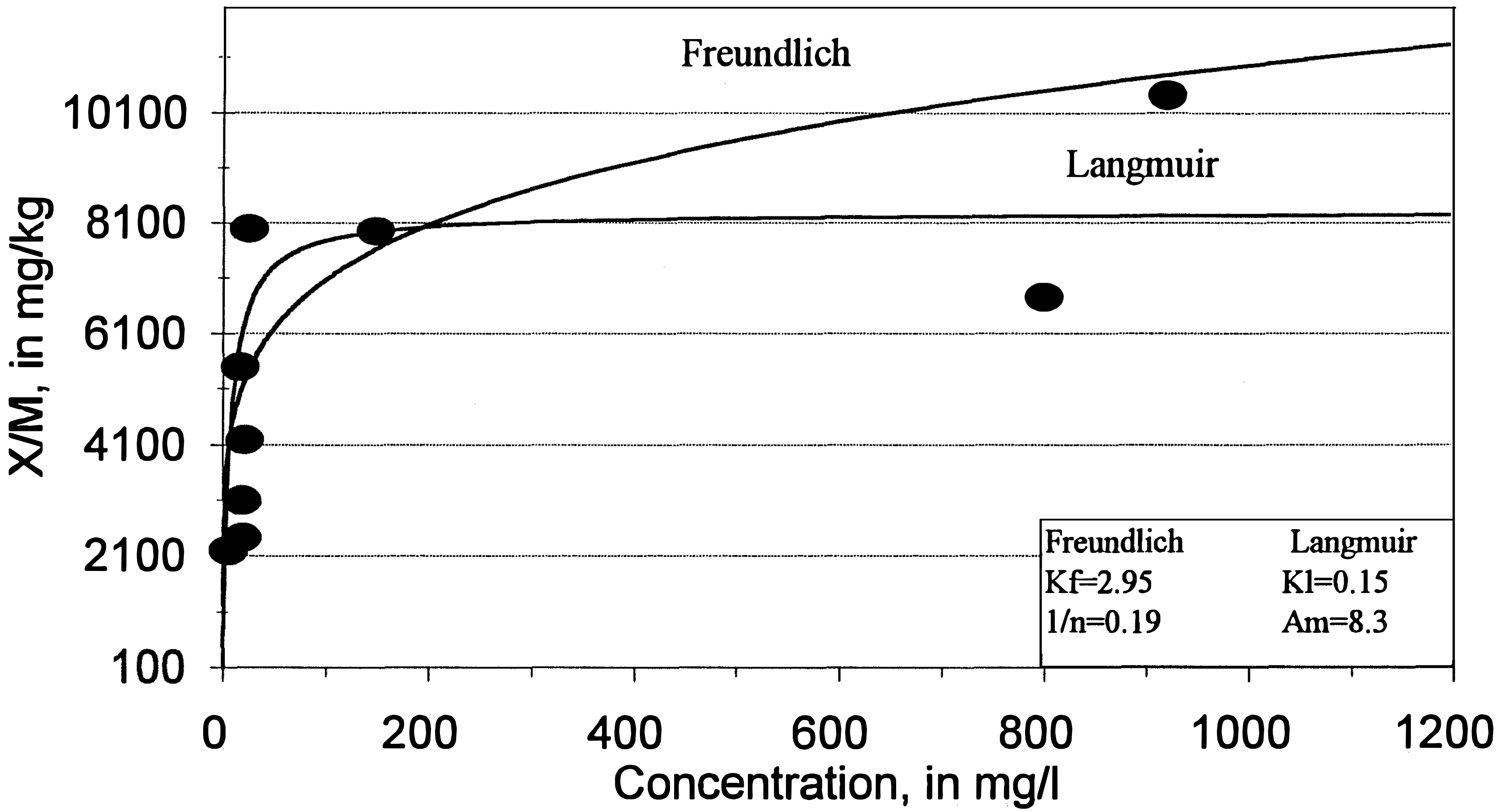



Figure 6. BIO1D flow paths and grid spacings for initial starting groundwater arsenic concentrations.

Figure 4. Measured arsenic concentration data for sediments and water versus the Langmuir and Freundlich calculated data.



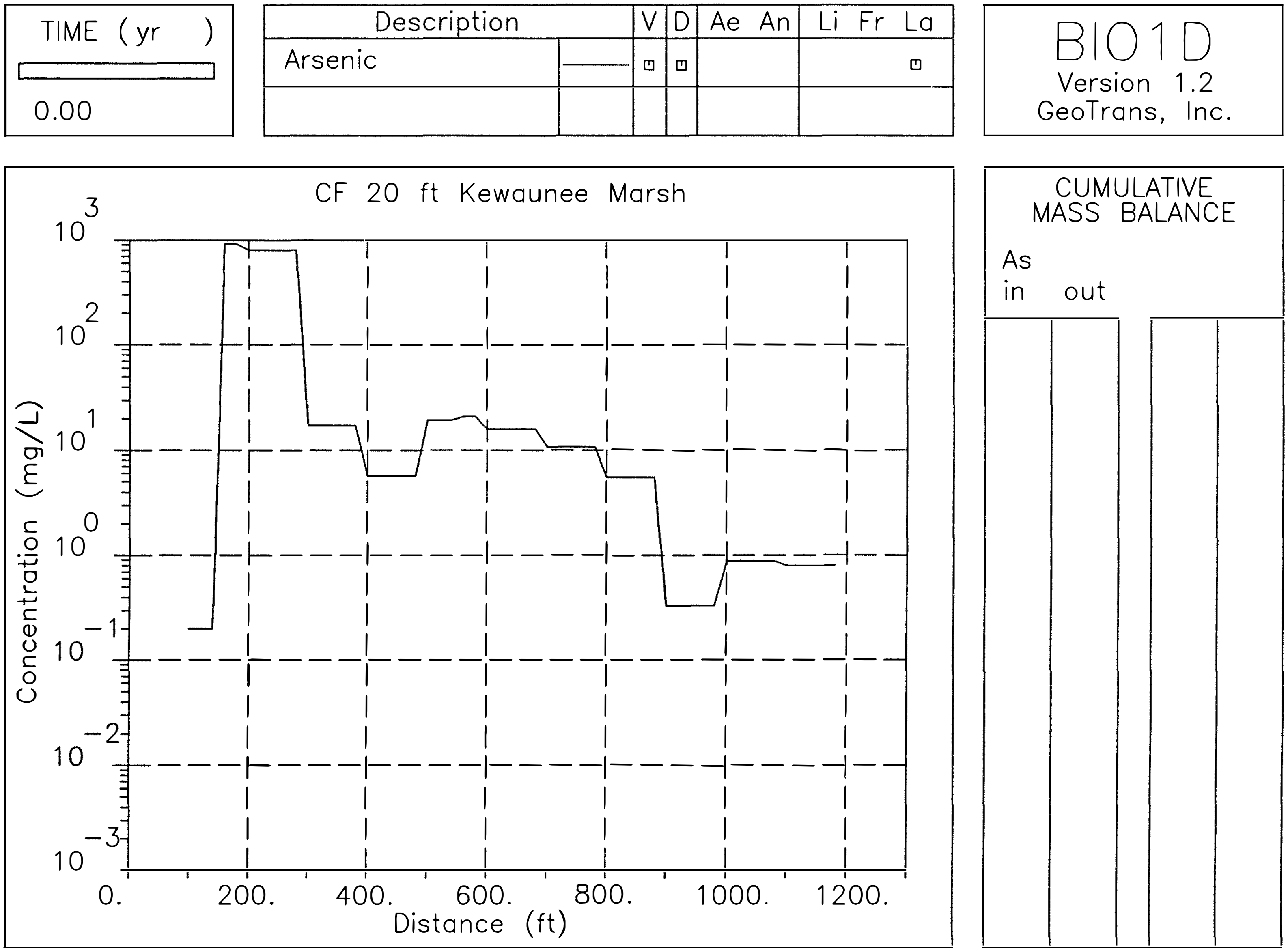



Figure 7. Initial arsenic concentrations in groundwater at the start of the model simulations for the Central Flow Path.

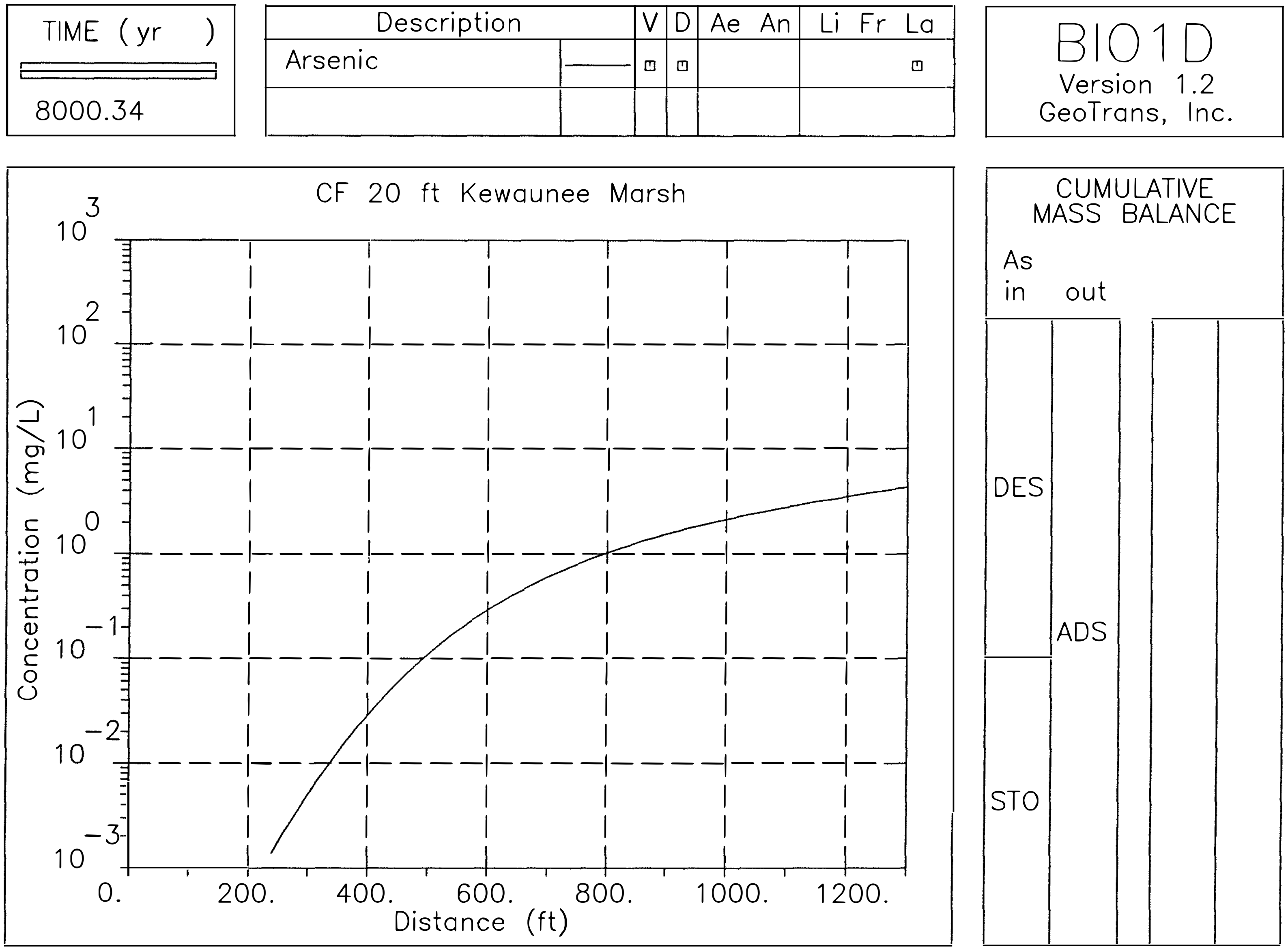



Figure 8. Groundwater arsenic concentrations as a function of distance for the Central Flow Path.

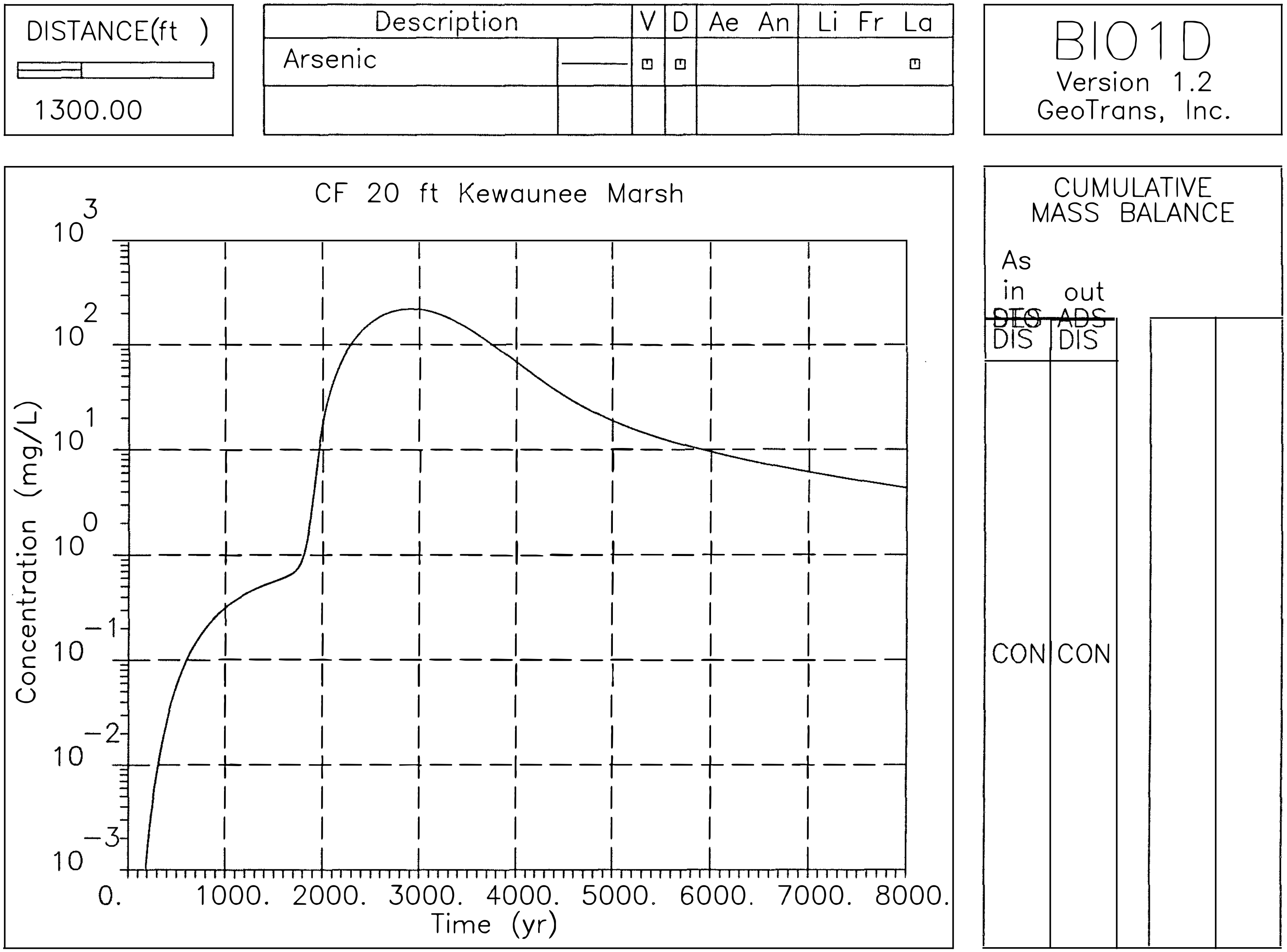



Figure 9. Groundwater arsenic concentrations discharging to river as a function of time for the Central Flow Path.

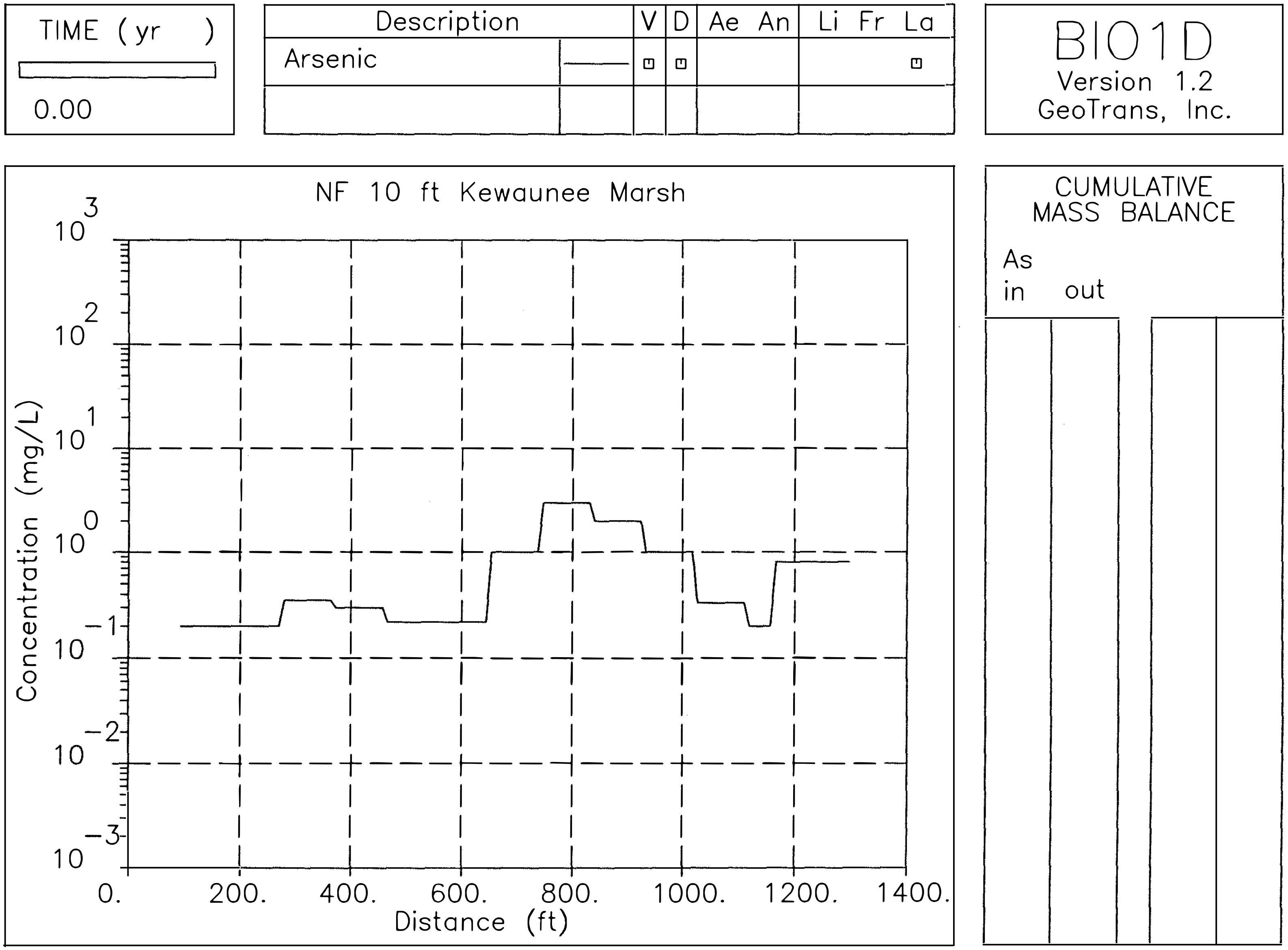



Figure 10. Initial arsenic concentrations in groundwater at the start of the model simulations for the Northern Flow Path.

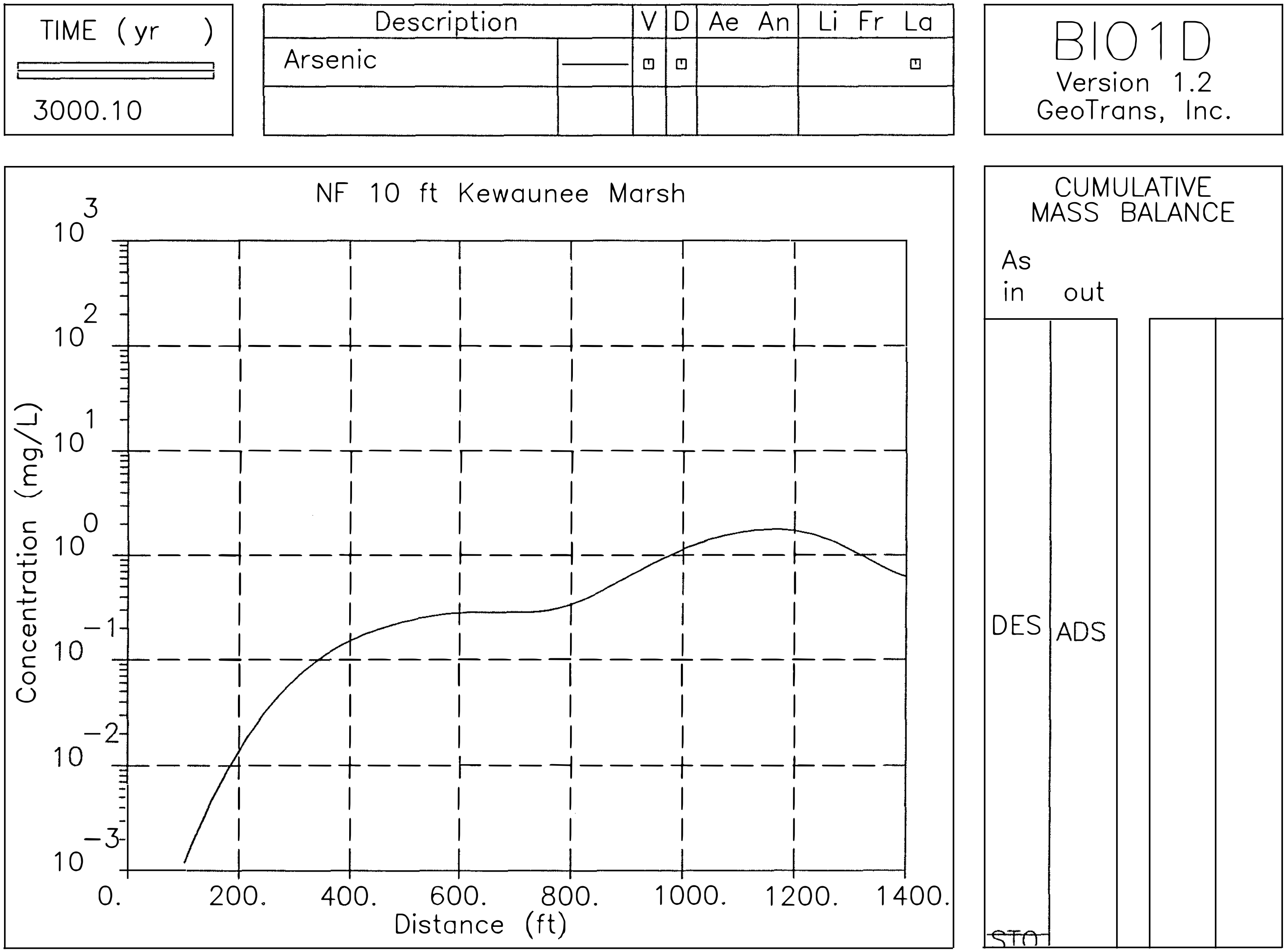



Figure 11. Groundwater arsenic concentrations as a function of distance between the marsh and river for the Northern Flow Path.

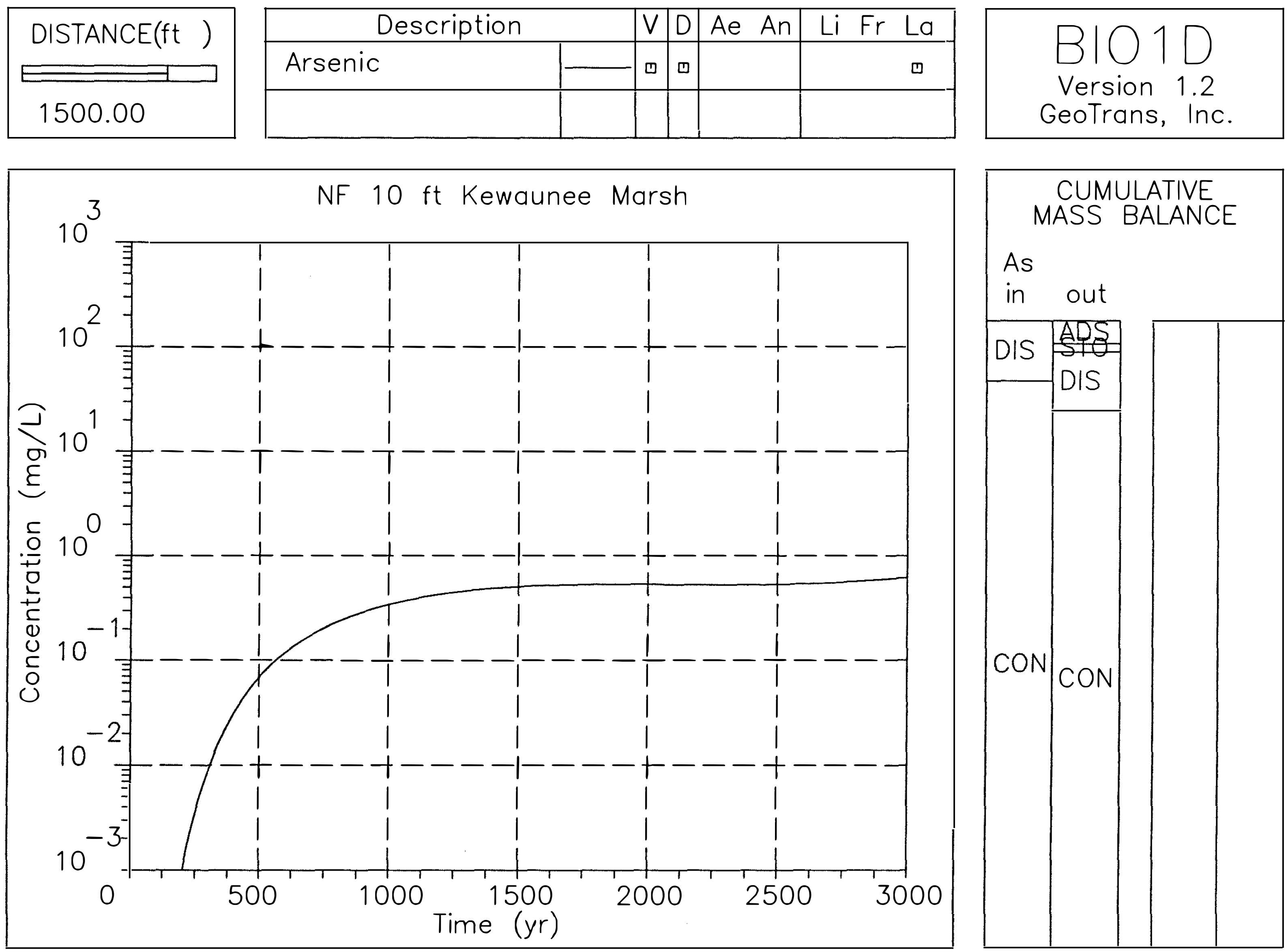



Figure 12. Groundwater arsenic concentrations discharging to the river as a function of time for the Northern Flow Path.

# APPENDIX C

Hydrocad Runoff Model Printouts

WATERSHED ROUTING ============================================================

| | | | |
|---|---|---|---|
| **SUBCATCHMENT 1** | = North Area (marsh) | -> | POND 1 |
| **SUBCATCHMENT 2** | = Central Area and Cap | -> | POND 1 |
| **SUBCATCHMENT 3** | = South Area | -> | POND 1 |
| **POND 1** | = Kewaunee River | -> | |

**RUNOFF BY SCS TR-20 METHOD: TYPE II 24-HOUR RAINFALL= 2.4 IN, SCS U.H.**

**RUNOFF SPAN = 10-20 HRS, dt= .10 HRS, 101 POINTS**

| SUBCAT NUMBER | AREA (ACRE) | Tc (MIN) | --GROUND | COVERS | (%CN)-- | | WGT'D CN | C | PEAK (CFS) | Tpeak (HRS) | VOL (AF) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.50 | 95.6 | 100%83 | - | - | - | 83 | - | 2.29 | 13.08 | .47 |
| 2 | 4.57 | 92.3 | 79%87 | 21%83 | - | - | 86 | - | 2.02 | 13.02 | .39 |
| 3 | 3.10 | 80.8 | 100%83 | - | - | - | 83 | - | 1.25 | 12.89 | .22 |

**REACH ROUTING BY STOR-IND+TRANS METHOD**

| REACH NO. | DIAM (IN) | BOTTOM WIDTH (FT) | DEPTH (FT) | SIDE SLOPES (FT/FT) | n | LENGTH (FT) | SLOPE (FT/FT) | PEAK VEL. (FPS) | TRAVEL TIME (MIN) | PEAK Qout (CFS) |
|---|---|---|---|---|---|---|---|---|---|---|

**POND ROUTING BY STOR-IND METHOD**

| POND NO. | START ELEV. (FT) | FLOOD ELEV. (FT) | PEAK ELEV. (FT) | PEAK STORAGE (AF) | ------ PEAK FLOW ------- Qin (CFS) | Qout (CFS) | Qpri (CFS) | Qsec (CFS) | ---Qout--- ATTEN. (%) | LAG (MIN) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 100.0 | 110.0 | 100.0 | 1.08 | 5.52 | 0.00 | | | 100 | 419.3 |

| LINK NO. | NAME | SOURCE | Qout (CFS) |
|---|---|---|---|

**SUBCATCHMENT 1** **North Area (marsh)**

PEAK= 2.29 CFS @ 13.08 HRS, VOLUME= .47 AF

| ACRES | CN | | |
|---|---|---|---|
| 6.50 | 83 | Marsh | SCS TR-20 METHOD<br>TYPE II 24-HOUR<br>RAINFALL= 2.4 IN<br>SPAN= 10-20 HRS, dt=.1 HRS |

| Method | Comment | Tc (min) |
|---|---|---|
| **CURVE NUMBER (LAG) METHOD**<br>L=1060' s=.001 '/' | **Flow thru marsh** | 95.6 |

**SUBCATCHMENT 2** **Central Area and Cap**

PEAK= 2.02 CFS @ 13.02 HRS, VOLUME= .39 AF

| ACRES | CN | | |
|---|---|---|---|
| 3.60 | 87 | Wood Chip Cap | SCS TR-20 METHOD |
| .97 | 83 | Marsh | TYPE II 24-HOUR |
| 4.57 | 86 | | RAINFALL= 2.4 IN<br>SPAN= 10-20 HRS, dt=.1 HRS |

| Method | Comment | Tc (min) |
|---|---|---|
| **CURVE NUMBER (LAG) METHOD**<br>L=780' s=.001 '/' | **Wood chips** | 67.4 |
| **CURVE NUMBER (LAG) METHOD**<br>L=225' s=.001 '/' | **Marsh** | 24.9 |
| | Total Length= 1005 ft Total Tc= | 92.3 |

**SUBCATCHMENT 3** **South Area**

PEAK= 1.25 CFS @ 12.89 HRS, VOLUME= .22 AF

| ACRES | CN | | |
|---|---|---|---|
| 3.10 | 83 | Marsh | SCS TR-20 METHOD<br>TYPE II 24-HOUR<br>RAINFALL= 2.4 IN<br>SPAN= 10-20 HRS, dt=.1 HRS |

| Method | Comment | Tc (min) |
|---|---|---|
| **CURVE NUMBER (LAG) METHOD**<br>L=860' s=.001 '/' | **Marsh** | 80.8 |

**POND 1** **Kewaunee River**

Qin = 5.52 CFS @ 13.01 HRS, VOLUME= 1.08 AF
Qout= 0.00 CFS @ 20.00 HRS, VOLUME= 0.00 AF, ATTEN=100%, LAG= 419.3 MIN

| ELEVATION (FT) | AREA (AC) | INC.STOR (AF) | CUM.STOR (AF) |
|---|---|---|---|
| 100.0 | 30.00 | 0.00 | 0.00 |
| 110.0 | 100.00 | 650.00 | 650.00 |

STOR-IND METHOD
PEAK STORAGE = 1.08 AF
PEAK ELEVATION= 100.0 FT
FLOOD ELEVATION= 110.0 FT
START ELEVATION= 100.0 FT
SPAN= 10-20 HRS, dt=.1 HRS
Tdet= 378.9 MIN (0 AF)

| # | ROUTE | INVERT | OUTLET DEVICES |
|---|---|---|---|
| 1 | P | 100.0' | **100" CULVERT**<br>n=.03 L=100' S=.001'/' Ke=.6 Cc=.9 Cd=.56 |

WATERSHED ROUTING ==========================================================

| | | | |
|---|---|---|---|
| **SUBCATCHMENT 1** | = North Area (marsh) | -> | POND 1 |
| **SUBCATCHMENT 2** | = Central Area and Cap | -> | POND 1 |
| **SUBCATCHMENT 3** | = South Area | -> | POND 1 |
| **POND 1** | = Kewaunee River | -> | |

**RUNOFF BY SCS TR-20 METHOD: TYPE II 24-HOUR RAINFALL= 3.2 IN, SCS U.H.**

**RUNOFF SPAN = 10-20 HRS, dt= .10 HRS, 101 POINTS**

| SUBCAT NUMBER | AREA (ACRE) | Tc (MIN) | --GROUND | COVERS | (%CN)-- | | WGT'D CN | C | PEAK (CFS) | Tpeak (HRS) | VOL (AF) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.50 | 95.6 | 100%83 | - | - | - | 83 | - | 3.88 | 13.05 | .77 |
| 2 | 4.57 | 92.3 | 79%87 | 21%83 | - | - | 86 | - | 3.23 | 13.00 | .62 |
| 3 | 3.10 | 80.8 | 100%83 | - | - | - | 83 | - | 2.11 | 12.86 | .37 |

**REACH ROUTING BY STOR-IND+TRANS METHOD**

| REACH NO. | DIAM (IN) | BOTTOM WIDTH (FT) | DEPTH (FT) | SIDE SLOPES (FT/FT) | n | LENGTH (FT) | SLOPE (FT/FT) | PEAK VEL. (FPS) | TRAVEL TIME (MIN) | PEAK Qout (CFS) |
|---|---|---|---|---|---|---|---|---|---|---|

**POND ROUTING BY STOR-IND METHOD**

| POND NO. | START ELEV. (FT) | FLOOD ELEV. (FT) | PEAK ELEV. (FT) | PEAK STORAGE (AF) | ------ PEAK FLOW ------- Qin (CFS) | Qout (CFS) | Qpri (CFS) | Qsec (CFS) | ---Qout--- ATTEN. (%) | LAG (MIN) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 100.0 | 110.0 | 100.0 | 1.76 | 9.15 | .01 | | | 100 | 420.5 |

| LINK NO. | NAME | SOURCE | Qout (CFS) |
|---|---|---|---|

**SUBCATCHMENT 1** **North Area (marsh)**

PEAK= 3.88 CFS @ 13.05 HRS, VOLUME= .77 AF

| ACRES | CN | |
|---|---|---|
| 6.50 | 83 | Marsh |

SCS TR-20 METHOD
TYPE II 24-HOUR
RAINFALL= 3.2 IN
SPAN= 10-20 HRS, dt=.1 HRS

| Method | Comment | Tc (min) |
|---|---|---|
| **CURVE NUMBER (LAG) METHOD**<br>L=1060' s=.001 '/' | **Flow thru marsh** | 95.6 |

**SUBCATCHMENT 2** **Central Area and Cap**

PEAK= 3.23 CFS @ 13.00 HRS, VOLUME= .62 AF

| ACRES | CN | |
|---|---|---|
| 3.60 | 87 | Wood Chip Cap |
| .97 | 83 | Marsh |
| 4.57 | 86 | |

SCS TR-20 METHOD
TYPE II 24-HOUR
RAINFALL= 3.2 IN
SPAN= 10-20 HRS, dt=.1 HRS

| Method | Comment | Tc (min) |
|---|---|---|
| **CURVE NUMBER (LAG) METHOD**<br>L=780' s=.001 '/' | **Wood chips** | 67.4 |
| **CURVE NUMBER (LAG) METHOD**<br>L=225' s=.001 '/' | **Marsh** | 24.9 |
| | Total Length= 1005 ft Total Tc= | 92.3 |

**SUBCATCHMENT 3** **South Area**

PEAK= 2.11 CFS @ 12.86 HRS, VOLUME= .37 AF

| ACRES | CN | |
|---|---|---|
| 3.10 | 83 | Marsh |

SCS TR-20 METHOD
TYPE II 24-HOUR
RAINFALL= 3.2 IN
SPAN= 10-20 HRS, dt=.1 HRS

| Method | Comment | Tc (min) |
|---|---|---|
| **CURVE NUMBER (LAG) METHOD**<br>L=860' s=.001 '/' | **Marsh** | 80.8 |

**POND 1** **Kewaunee River**

Qin = 9.15 CFS @ 12.99 HRS, VOLUME= 1.77 AF
Qout= .01 CFS @ 20.00 HRS, VOLUME= 0.00 AF, ATTEN=100%, LAG= 420.5 MIN

| ELEVATION (FT) | AREA (AC) | INC.STOR (AF) | CUM.STOR (AF) |
|---|---|---|---|
| 100.0 | 30.00 | 0.00 | 0.00 |
| 110.0 | 100.00 | 650.00 | 650.00 |

STOR-IND METHOD
PEAK STORAGE = 1.76 AF
PEAK ELEVATION= 100.0 FT
FLOOD ELEVATION= 110.0 FT
START ELEVATION= 100.0 FT
SPAN= 10-20 HRS, dt=.1 HRS
Tdet= 399.3 MIN (0 AF)

| # | ROUTE | INVERT | OUTLET DEVICES |
|---|---|---|---|
| 1 | P | 100.0' | **100" CULVERT**<br>n=.03 L=100' S=.001'/' Ke=.6 Cc=.9 Cd=.56 |

WATERSHED ROUTING ============================================================

| | | | |
|---|---|---|---|
| **SUBCATCHMENT 1** | = North Area (marsh) | -> | POND 1 |
| **SUBCATCHMENT 2** | = Central Area and Cap | -> | POND 1 |
| **SUBCATCHMENT 3** | = South Area | -> | POND 1 |
| **POND 1** | = Kewaunee River | -> | |

**RUNOFF BY SCS TR-20 METHOD: TYPE II 24-HOUR RAINFALL= 3.7 IN, SCS U.H.**

**RUNOFF SPAN = 10-20 HRS, dt= .10 HRS, 101 POINTS**

| SUBCAT NUMBER | AREA (ACRE) | Tc (MIN) | --GROUND | COVERS | (%CN)-- | | WGT'D CN | C | PEAK (CFS) | Tpeak (HRS) | VOL (AF) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.50 | 95.6 | 100%83 | - | - | - | 83 | - | 4.93 | 13.04 | .98 |
| 2 | 4.57 | 92.3 | 79%87 | 21%83 | - | - | 86 | - | 4.02 | 12.99 | .77 |
| 3 | 3.10 | 80.8 | 100%83 | - | - | - | 83 | - | 2.68 | 12.85 | .47 |

**REACH ROUTING BY STOR-IND+TRANS METHOD**

| REACH NO. | DIAM (IN) | BOTTOM WIDTH (FT) | DEPTH (FT) | SIDE SLOPES (FT/FT) | n | LENGTH (FT) | SLOPE (FT/FT) | PEAK VEL. (FPS) | TRAVEL TIME (MIN) | PEAK Qout (CFS) |
|---|---|---|---|---|---|---|---|---|---|---|

**POND ROUTING BY STOR-IND METHOD**

| POND NO. | START ELEV. (FT) | FLOOD ELEV. (FT) | PEAK ELEV. (FT) | PEAK STORAGE (AF) | ------ PEAK FLOW ------- Qin (CFS) | Qout (CFS) | Qpri (CFS) | Qsec (CFS) | ---Qout--- ATTEN. (%) | LAG (MIN) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 100.0 | 110.0 | 100.0 | 2.22 | 11.54 | .01 | | | 100 | 421.0 |

| LINK NO. | NAME | SOURCE | Qout (CFS) |
|---|---|---|---|

**SUBCATCHMENT 1** **North Area (marsh)**

PEAK= 4.93 CFS @ 13.04 HRS, VOLUME= .98 AF

| ACRES | CN | |
|---|---|---|
| 6.50 | 83 | Marsh |

SCS TR-20 METHOD
TYPE II 24-HOUR
RAINFALL= 3.7 IN
SPAN= 10-20 HRS, dt=.1 HRS

| Method | Comment | Tc (min) |
|---|---|---|
| **CURVE NUMBER (LAG) METHOD**<br>L=1060' s=.001 '/' | **Flow thru marsh** | 95.6 |

**SUBCATCHMENT 2** **Central Area and Cap**

PEAK= 4.02 CFS @ 12.99 HRS, VOLUME= .77 AF

| ACRES | CN | |
|---|---|---|
| 3.60 | 87 | Wood Chip Cap |
| .97 | 83 | Marsh |
| 4.57 | 86 | |

SCS TR-20 METHOD
TYPE II 24-HOUR
RAINFALL= 3.7 IN
SPAN= 10-20 HRS, dt=.1 HRS

| Method | Comment | Tc (min) |
|---|---|---|
| **CURVE NUMBER (LAG) METHOD**<br>L=780' s=.001 '/' | **Wood chips** | 67.4 |
| **CURVE NUMBER (LAG) METHOD**<br>L=225' s=.001 '/' | **Marsh** | 24.9 |
| | Total Length= 1005 ft Total Tc= | 92.3 |

**SUBCATCHMENT 3** **South Area**

PEAK= 2.68 CFS @ 12.85 HRS, VOLUME= .47 AF

| ACRES | CN | |
|---|---|---|
| 3.10 | 83 | Marsh |

SCS TR-20 METHOD
TYPE II 24-HOUR
RAINFALL= 3.7 IN
SPAN= 10-20 HRS, dt=.1 HRS

| Method | Comment | Tc (min) |
|---|---|---|
| **CURVE NUMBER (LAG) METHOD**<br>L=860' s=.001 '/' | **Marsh** | 80.8 |

**POND 1** **Kewaunee River**

Qin = 11.54 CFS @ 12.98 HRS, VOLUME= 2.22 AF
Qout= .01 CFS @ 20.00 HRS, VOLUME= 0.00 AF, ATTEN=100%, LAG= 421.0 MIN

| ELEVATION (FT) | AREA (AC) | INC.STOR (AF) | CUM.STOR (AF) |
|---|---|---|---|
| 100.0 | 30.00 | 0.00 | 0.00 |
| 110.0 | 100.00 | 650.00 | 650.00 |

STOR-IND METHOD
PEAK STORAGE = 2.22 AF
PEAK ELEVATION= 100.0 FT
FLOOD ELEVATION= 110.0 FT
START ELEVATION= 100.0 FT
SPAN= 10-20 HRS, dt=.1 HRS
Tdet= 402.8 MIN (0 AF)

| # | ROUTE | INVERT | OUTLET DEVICES |
|---|---|---|---|
| 1 | P | 100.0' | **100" CULVERT**<br>n=.03 L=100' S=.001'/' Ke=.6 Cc=.9 Cd=.56 |

WATERSHED ROUTING ============================================================

| | | | |
|---|---|---|---|
| **SUBCATCHMENT 1** | = North Area (marsh) | -> | POND 1 |
| **SUBCATCHMENT 2** | = Central Area and Cap | -> | POND 1 |
| **SUBCATCHMENT 3** | = South Area | -> | POND 1 |
| **POND 1** | = Kewaunee River | -> | |

**RUNOFF BY SCS TR-20 METHOD: TYPE II 24-HOUR RAINFALL= 4.2 IN, SCS U.H.**

**RUNOFF SPAN = 10-20 HRS, dt= .10 HRS, 101 POINTS**

| SUBCAT NUMBER | AREA (ACRE) | Tc (MIN) | --GROUND | COVERS | (%CN)-- | | WGT'D CN | C | PEAK (CFS) | Tpeak (HRS) | VOL (AF) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.50 | 95.6 | 100%83 | - | - | - | 83 | - | 6.01 | 13.03 | 1.19 |
| 2 | 4.57 | 92.3 | 79%87 | 21%83 | - | - | 86 | - | 4.82 | 12.99 | .93 |
| 3 | 3.10 | 80.8 | 100%83 | - | - | - | 83 | - | 3.26 | 12.84 | .57 |

**REACH ROUTING BY STOR-IND+TRANS METHOD**

| REACH NO. | DIAM (IN) | BOTTOM WIDTH (FT) | DEPTH (FT) | SIDE SLOPES (FT/FT) | n | LENGTH (FT) | SLOPE (FT/FT) | PEAK VEL. (FPS) | TRAVEL TIME (MIN) | PEAK Qout (CFS) |
|---|---|---|---|---|---|---|---|---|---|---|

**POND ROUTING BY STOR-IND METHOD**

| POND NO. | START ELEV. (FT) | FLOOD ELEV. (FT) | PEAK ELEV. (FT) | PEAK STORAGE (AF) | ------ PEAK FLOW ------- Qin (CFS) | Qout (CFS) | Qpri (CFS) | Qsec (CFS) | ---Qout--- ATTEN. (%) | LAG (MIN) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 100.0 | 110.0 | 100.0 | 2.68 | 13.98 | .01 | | | 100 | 421.4 |

| LINK NO. | NAME | SOURCE | Qout (CFS) |
|---|---|---|---|

**SUBCATCHMENT 1** **North Area (marsh)**

PEAK= 6.01 CFS @ 13.03 HRS, VOLUME= 1.19 AF

| ACRES | CN | |
|---|---|---|
| 6.50 | 83 | Marsh |

SCS TR-20 METHOD
TYPE II 24-HOUR
RAINFALL= 4.2 IN
SPAN= 10-20 HRS, dt=.1 HRS

| Method | Comment | Tc (min) |
|---|---|---|
| **CURVE NUMBER (LAG) METHOD** | **Flow thru marsh** | 95.6 |
| L=1060' s=.001 '/' | | |

**SUBCATCHMENT 2** **Central Area and Cap**

PEAK= 4.82 CFS @ 12.99 HRS, VOLUME= .93 AF

| ACRES | CN | |
|---|---|---|
| 3.60 | 87 | Wood Chip Cap |
| .97 | 83 | Marsh |
| 4.57 | 86 | |

SCS TR-20 METHOD
TYPE II 24-HOUR
RAINFALL= 4.2 IN
SPAN= 10-20 HRS, dt=.1 HRS

| Method | Comment | Tc (min) |
|---|---|---|
| **CURVE NUMBER (LAG) METHOD** | **Wood chips** | 67.4 |
| L=780' s=.001 '/' | | |
| **CURVE NUMBER (LAG) METHOD** | **Marsh** | 24.9 |
| L=225' s=.001 '/' | | |
| | | ---------- |
| | Total Length= 1005 ft Total Tc= | 92.3 |

**SUBCATCHMENT 3** **South Area**

PEAK= 3.26 CFS @ 12.84 HRS, VOLUME= .57 AF

| ACRES | CN | |
|---|---|---|
| 3.10 | 83 | Marsh |

SCS TR-20 METHOD
TYPE II 24-HOUR
RAINFALL= 4.2 IN
SPAN= 10-20 HRS, dt=.1 HRS

| Method | Comment | Tc (min) |
|---|---|---|
| **CURVE NUMBER (LAG) METHOD** | **Marsh** | 80.8 |
| L=860' s=.001 '/' | | |

**POND 1** **Kewaunee River**

Qin = 13.98 CFS @ 12.98 HRS, VOLUME= 2.69 AF
Qout= .01 CFS @ 20.00 HRS, VOLUME= 0.00 AF, ATTEN=100%, LAG= 421.4 MIN

| ELEVATION (FT) | AREA (AC) | INC.STOR (AF) | CUM.STOR (AF) |
|---|---|---|---|
| 100.0 | 30.00 | 0.00 | 0.00 |
| 110.0 | 100.00 | 650.00 | 650.00 |

STOR-IND METHOD
PEAK STORAGE = 2.68 AF
PEAK ELEVATION= 100.0 FT
FLOOD ELEVATION= 110.0 FT
START ELEVATION= 100.0 FT
SPAN= 10-20 HRS, dt=.1 HRS
Tdet= 403 MIN (0 AF)

| # | ROUTE | INVERT | OUTLET DEVICES |
|---|---|---|---|
| 1 | P | 100.0' | **100" CULVERT**<br>n=.03 L=100' S=.001'/' Ke=.6 Cc=.9 Cd=.56 |

WATERSHED ROUTING ============================================================

| | | | |
|---|---|---|---|
| **SUBCATCHMENT 1** | = North Area (marsh) | -> | POND 1 |
| **SUBCATCHMENT 2** | = Central Area and Cap | -> | POND 1 |
| **SUBCATCHMENT 3** | = South Area | -> | POND 1 |
| **POND 1** | = Kewaunee River | -> | |

**RUNOFF BY SCS TR-20 METHOD: TYPE II 24-HOUR RAINFALL= 4.7 IN, SCS U.H.**

**RUNOFF SPAN = 10-20 HRS, dt= .10 HRS, 101 POINTS**

| SUBCAT NUMBER | AREA (ACRE) | Tc (MIN) | --GROUND | COVERS | (%CN) | -- | WGT'D CN | C | PEAK (CFS) | Tpeak (HRS) | VOL (AF) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.50 | 95.6 | 100%83 | - | - | - | 83 | - | 7.11 | 13.03 | 1.40 |
| 2 | 4.57 | 92.3 | 79%87 | 21%83 | - | - | 86 | - | 5.63 | 12.98 | 1.08 |
| 3 | 3.10 | 80.8 | 100%83 | - | - | - | 83 | - | 3.86 | 12.84 | .67 |

**REACH ROUTING BY STOR-IND+TRANS METHOD**

| REACH NO. | DIAM (IN) | BOTTOM WIDTH (FT) | DEPTH (FT) | SIDE SLOPES (FT/FT) | n | LENGTH (FT) | SLOPE (FT/FT) | PEAK VEL. (FPS) | TRAVEL TIME (MIN) | PEAK Qout (CFS) |
|---|---|---|---|---|---|---|---|---|---|---|

**POND ROUTING BY STOR-IND METHOD**

| POND NO. | START ELEV. (FT) | FLOOD ELEV. (FT) | PEAK ELEV. (FT) | PEAK STORAGE (AF) | ------ PEAK FLOW ------- Qin (CFS) | Qout (CFS) | Qpri (CFS) | Qsec (CFS) | ---Qout--- ATTEN. (%) | LAG (MIN) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 100.0 | 110.0 | 100.0 | 3.15 | 16.46 | .01 | | | 100 | 421.7 |

| LINK NO. | NAME | SOURCE | Qout (CFS) |
|---|---|---|---|

**SUBCATCHMENT 1** **North Area (marsh)**

PEAK= 7.11 CFS @ 13.03 HRS, VOLUME= 1.40 AF

| ACRES | CN | | |
|---|---|---|---|
| 6.50 | 83 | Marsh | SCS TR-20 METHOD<br>TYPE II 24-HOUR<br>RAINFALL= 4.7 IN<br>SPAN= 10-20 HRS, dt=.1 HRS |

| Method | Comment | Tc (min) |
|---|---|---|
| **CURVE NUMBER (LAG) METHOD**<br>L=1060' s=.001 '/' | **Flow thru marsh** | 95.6 |

**SUBCATCHMENT 2** **Central Area and Cap**

PEAK= 5.63 CFS @ 12.98 HRS, VOLUME= 1.08 AF

| ACRES | CN | | |
|---|---|---|---|
| 3.60 | 87 | Wood Chip Cap | SCS TR-20 METHOD |
| .97 | 83 | Marsh | TYPE II 24-HOUR |
| 4.57 | 86 | | RAINFALL= 4.7 IN<br>SPAN= 10-20 HRS, dt=.1 HRS |

| Method | Comment | Tc (min) |
|---|---|---|
| **CURVE NUMBER (LAG) METHOD**<br>L=780' s=.001 '/' | **Wood chips** | 67.4 |
| **CURVE NUMBER (LAG) METHOD**<br>L=225' s=.001 '/' | **Marsh** | 24.9 |
| | Total Length= 1005 ft Total Tc= | 92.3 |

**SUBCATCHMENT 3** **South Area**

PEAK= 3.86 CFS @ 12.84 HRS, VOLUME= .67 AF

| ACRES | CN | | |
|---|---|---|---|
| 3.10 | 83 | Marsh | SCS TR-20 METHOD<br>TYPE II 24-HOUR<br>RAINFALL= 4.7 IN<br>SPAN= 10-20 HRS, dt=.1 HRS |

| Method | Comment | Tc (min) |
|---|---|---|
| **CURVE NUMBER (LAG) METHOD**<br>L=860' s=.001 '/' | **Marsh** | 80.8 |

**POND 1** **Kewaunee River**

Qin = 16.46 CFS @ 12.97 HRS, VOLUME= 3.16 AF
Qout= .01 CFS @ 20.00 HRS, VOLUME= 0.00 AF, ATTEN=100%, LAG= 421.7 MIN

| ELEVATION (FT) | AREA (AC) | INC.STOR (AF) | CUM.STOR (AF) |
|---|---|---|---|
| 100.0 | 30.00 | 0.00 | 0.00 |
| 110.0 | 100.00 | 650.00 | 650.00 |

STOR-IND METHOD
PEAK STORAGE = 3.15 AF
PEAK ELEVATION= 100.0 FT
FLOOD ELEVATION= 110.0 FT
START ELEVATION= 100.0 FT
SPAN= 10-20 HRS, dt=.1 HRS
Tdet= 400.8 MIN (0 AF)

| # | ROUTE | INVERT | OUTLET DEVICES |
|---|---|---|---|
| 1 | P | 100.0' | **100" CULVERT**<br>n=.03 L=100' S=.001'/' Ke=.6 Cc=.9 Cd=.56 |

WATERSHED ROUTING ==========================================================

| | | | |
|---|---|---|---|
| **SUBCATCHMENT 1** | = North Area (marsh) | -> | POND 1 |
| **SUBCATCHMENT 2** | = Central Area and Cap | -> | POND 1 |
| **SUBCATCHMENT 3** | = South Area | -> | POND 1 |
| **POND 1** | = Kewaunee River | -> | |

**RUNOFF BY SCS TR-20 METHOD: TYPE II 24-HOUR RAINFALL= 5.0 IN, SCS U.H.**

**RUNOFF SPAN = 10-20 HRS, dt= .10 HRS, 101 POINTS**

| SUBCAT NUMBER | AREA (ACRE) | Tc (MIN) | --GROUND | COVERS | (%CN)-- | | WGT'D CN | C | PEAK (CFS) | Tpeak (HRS) | VOL (AF) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 6.50 | 95.6 | 100%83 | - | - | - | 83 | - | 7.77 | 13.02 | 1.53 |
| 2 | 4.57 | 92.3 | 79%87 | 21%83 | - | - | 86 | - | 6.12 | 12.98 | 1.17 |
| 3 | 3.10 | 80.8 | 100%83 | - | - | - | 83 | - | 4.22 | 12.84 | .73 |

**REACH ROUTING BY STOR-IND+TRANS METHOD**

| REACH NO. | DIAM (IN) | BOTTOM WIDTH (FT) | DEPTH (FT) | SIDE SLOPES (FT/FT) | n | LENGTH (FT) | SLOPE (FT/FT) | PEAK VEL. (FPS) | TRAVEL TIME (MIN) | PEAK Qout (CFS) |
|---|---|---|---|---|---|---|---|---|---|---|

**POND ROUTING BY STOR-IND METHOD**

| POND NO. | START ELEV. (FT) | FLOOD ELEV. (FT) | PEAK ELEV. (FT) | PEAK STORAGE (AF) | ------ PEAK FLOW ------- Qin (CFS) | Qout (CFS) | Qpri (CFS) | Qsec (CFS) | ---Qout--- ATTEN. (%) | LAG (MIN) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 100.0 | 110.0 | 100.1 | 3.43 | 17.96 | .01 | | | 100 | 421.8 |

| LINK NO. | NAME | SOURCE | Qout (CFS) |
|---|---|---|---|

**SUBCATCHMENT 1** **North Area (marsh)**

PEAK= 7.77 CFS @ 13.02 HRS, VOLUME= 1.53 AF

| ACRES | CN | |
|---|---|---|
| 6.50 | 83 | Marsh |

SCS TR-20 METHOD
TYPE II 24-HOUR
RAINFALL= 5.0 IN
SPAN= 10-20 HRS, dt=.1 HRS

| Method | Comment | Tc (min) |
|---|---|---|
| **CURVE NUMBER (LAG) METHOD**<br>L=1060' s=.001 '/' | **Flow thru marsh** | 95.6 |

**SUBCATCHMENT 2** **Central Area and Cap**

PEAK= 6.12 CFS @ 12.98 HRS, VOLUME= 1.17 AF

| ACRES | CN | |
|---|---|---|
| 3.60 | 87 | Wood Chip Cap |
| .97 | 83 | Marsh |
| 4.57 | 86 | |

SCS TR-20 METHOD
TYPE II 24-HOUR
RAINFALL= 5.0 IN
SPAN= 10-20 HRS, dt=.1 HRS

| Method | Comment | Tc (min) |
|---|---|---|
| **CURVE NUMBER (LAG) METHOD**<br>L=780' s=.001 '/' | **Wood chips** | 67.4 |
| **CURVE NUMBER (LAG) METHOD**<br>L=225' s=.001 '/' | **Marsh** | 24.9 |
| | | ---------- |
| | Total Length= 1005 ft Total Tc= | 92.3 |

**SUBCATCHMENT 3** **South Area**

PEAK= 4.22 CFS @ 12.84 HRS, VOLUME= .73 AF

| ACRES | CN | |
|---|---|---|
| 3.10 | 83 | Marsh |

SCS TR-20 METHOD
TYPE II 24-HOUR
RAINFALL= 5.0 IN
SPAN= 10-20 HRS, dt=.1 HRS

| Method | Comment | Tc (min) |
|---|---|---|
| **CURVE NUMBER (LAG) METHOD**<br>L=860' s=.001 '/' | **Marsh** | 80.8 |

**POND 1** **Kewaunee River**

Qin = 17.96 CFS @ 12.97 HRS, VOLUME= 3.44 AF
Qout= .01 CFS @ 20.00 HRS, VOLUME= 0.00 AF, ATTEN=100%, LAG= 421.8 MIN

| ELEVATION (FT) | AREA (AC) | INC.STOR (AF) | CUM.STOR (AF) |
|---|---|---|---|
| 100.0 | 30.00 | 0.00 | 0.00 |
| 110.0 | 100.00 | 650.00 | 650.00 |

STOR-IND METHOD
PEAK STORAGE = 3.43 AF
PEAK ELEVATION= 100.1 FT
FLOOD ELEVATION= 110.0 FT
START ELEVATION= 100.0 FT
SPAN= 10-20 HRS, dt=.1 HRS
Tdet= 402.6 MIN (0 AF)

| # | ROUTE | INVERT | OUTLET DEVICES |
|---|---|---|---|
| 1 | P | 100.0' | **100" CULVERT**<br>n=.03 L=100' S=.001'/' Ke=.6 Cc=.9 Cd=.56 |