RECLAMATION LIABILITY RELEASE APPLICATION
ADMINISTRATIVE COMPLETENESS CHECKLIST
J-1, N-6, J-16, AND N-14 AREAS

CHECKLIST ITEM	APPLICABLE APPLICATION SECTION
Maps, 30 CFR 715.11(c)(1) & (d)(1)	Tab 1
Comparison of premine slopes with Postmine slopes, 30 CFR 715.14(a) & (b)	Tab 2
Acid and toxic forming materials, 30 CFR 715.14(j) & 715.17(g)	Tab 4
Small depressions, 30 CFR 715.14(d)	Tab 2
Permanent impoundments, 30 CFR 715.14(e) & 715.17(k)	Tab 6
Topsoil handling, 30 CFR 715.16(b) & (d)	Tab 4
Surface water, 30 CFR 715.17(b)(2)	Tab 3
Diversion of overland flow, 30 CFR 715.17(c)(2) & (3)	Tab 6
Stream channel diversions, 30 CFR 715.17(d)	N/A
Sedimentation pond removal, 30 CFR 715.17(e)(21)	N/A
Groundwater, 30 CFR 715.17(h)(1), (2), & (3)	Tab 3
Roads, 30 CFR 715.17(l)	Tab 6
Revegetation: general 30 CFR 715.20 (a)	Tab 5
Methods of revegetation, 30 CFR 715.20 (e)	Tab 5
Measuring revegetation success, 30 CFR 715.20(f)	Tab 5
Special requirements or conditions required by interim permits and/or mining plans	N/A

Reclamation Liability Release Application (RLRA)

N-6, J-1, J-16, and N-14 INITIAL PROGRAM LANDS
KAYENTA COMPLEX

INDEX VOLUME

CERTIFICATION OF RECLAMATION

Peabody Western Coal Company certifies that all reclamation activities conducted in the J-1, N-6, J-16, and N-14 mining areas identified in the August 2019 application for final release of reclamation liability were accomplished in accordance with applicable requirements of the Surface Mining Control and Reclamation Act, the regulatory program, and the approved reclamation plan.

[SEAL]

Dated this 26th day of August 2019

Name: Randy S. Lehn

Title: Director, Operations Support

STATE OF ARIZONA)
) ss.
COUNTY OF COCONINO)

The foregoing instrument was acknowledged before me by Randy S. Lehn, Director, Operations Support of Peabody Western Coal Company, this 26th day of August 2019.

LORETTA JONES
Notary Public - Arizona
Navajo County
Commission # 548873
My Comm. Expires Aug 14, 2022

Loretta Jones
Notary Public

My commission expires:

August 14, 2022

PEABODY
WESTERN

Peabody Western Coal Company

Mr. Jeremy Spangler
Western Region Office
Office of Surface Mining Reclamation & Enforcement
1999 Broadway, Suite 3320
Denver, CO 80202-3050

August 26, 2019

RE: Submittal of Reclamation Liability Release Application, Peabody Western Coal Company, Kayenta Complex N-6, J-1, J-16, and N-14 Initial Program Release Areas

Dear Mr. Spangler:

Peabody Western Coal Company (PWCC) submits to the Office of Surface Mining Reclamation and Enforcement (OSMRE) the enclosed application materials in accordance with 30 CFR 700.11 (d)(1) for final release of reclamation liability on approximately 2,981 acres of mined and reclaimed lands in the N-6, J-1, J-16, and N-14 mining areas at the Kayenta Complex. Enclosed, please find one electronic CD of the Reclaimed Lands Release Application (RLRA).

The N-6, J-1, J-16, and N-14 reclaimed lands are subject to the Initial Program Performance Standards at 30 CFR 715, Subpart B only, because they were disturbed on or after December 16, 1977 and prior to issuance of Permanent Program permits pursuant to 30 CFR 750. It is our opinion, based upon the information contained in this RLRA, that the reclamation of these lands has been satisfactorily completed regarding the applicable performance standards and release criteria.

PWCC seeks the final release of reclamation liability so the subject lands can be made available for use by the Navajo Nation. PWCC no longer requires exclusive use of the N-6, J-1, J-16 and N-14 reseeded mined lands included with this RLRA; thus, local residents would once again gain use of them. By relinquishing its exclusive use, PWCC is not surrendering and terminating the coal leases for these 2,981 acres of seeded lands. To do so would create administrative and logistical problems, since these lands are near mining facilities associated with active mining and reclamation operations.

Although the surface mineable coal has been removed from the subject lands, their proximity to the mining and reclamation activities and the possibility that future uses of a portion of the lands may be necessary requires PWCC to maintain its lease rights on these lands. Future uses could include such things as pipelines, power lines, roads, environmental sites, or other mining and reclamation facilities. These future activities will be permitted and approved by OSMRE prior to construction of these support facilities. Therefore, this application approval will also complete the reclamation liability requirements in PWCC's coal leases.

The format for the electronic files on the CD is for the most part in a PDF format. Should you have any questions regarding the application, please contact me at (928) 677-5130.

Respectfully,

Marie Shepherd
Sr. Manager Environmental
Kayenta Mine

MS
Encl.

C: A. McGregor (OSM-Denver)

VERIFICATION

I verify under oath that the information contained in this application for a permit; revision; termination of jurisdiction; renewal; or transfer, sales or assignments of permit rights is true and correct to the best of my information and belief.

Signature of Responsible Official ________________

Title Director Operations Support Date 8/26/2019

SUBSCRIBED AND SWORN TO BEFORE ME BY Randy S. Lehn

This 26th Day of August 2019

NOTARY PUBLIC Loretta Jones, 8/26/19

MY COMMISSION EXPIRES August 14, 2022

LORETTA JONES
Notary Public - Arizona
Navajo County
Commission # 548873
My Comm. Expires Aug 14, 2022

TAB 1

Introduction

J-1, N-6, J-16, and N-14

Reclamation Liability Release Application (RLRA)

TAB 1

TABLE OF CONTENTS

TAB 1

Introduction

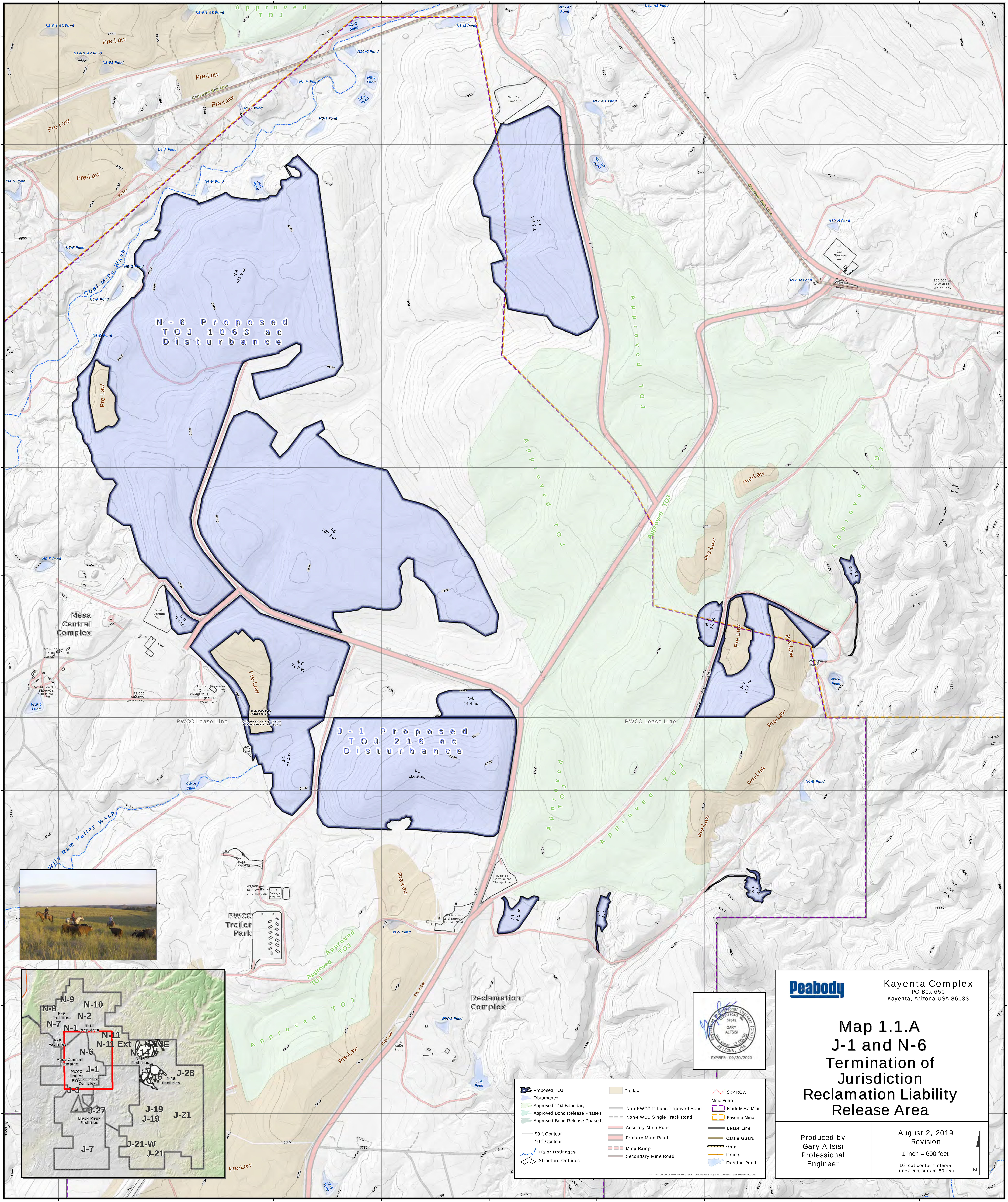
Peabody Western Coal Company, (PWCC) operates the Kayenta Complex mining operation on the Black Mesa, Navajo County, Arizona. The Kayenta Complex includes former mines separately designated as Black Mesa Mine and Kayenta Mine that began operations during 1970 and 1973, respectfully. The Kayenta Complex is located on contiguous leases within the boundaries of the Navajo and Hopi Indian Reservations. The Peabody leasehold covers 65,858 acres on the southern part of the mesa just south of Kayenta, Arizona with an additional Grant of Easement Right-of-Way for 360.94 acres.

The mines have been operated pursuant to interim program authorization and Permanent Program permits issued by the Office of Surface Mining Reclamation and Enforcement Western Region (OSMRE). The Kayenta Mine operates under Permanent Program Permit AZ-0001F and the Black Mesa Mine formerly operated under Interim Program authorization. The Black Mesa Mine ceased shipping coal to the Black Mesa Pipeline Company as of December 31, 2005. The Permanent Program Permit was issued on July 6, 1990. The Permanent Program Permit is AZ-0001F and was renewed five times; on July 6, 1995, on July 6, 2000, on July 6, 2005, on July 6, 2010, and lastly on July 6, 2015.

This document provides technical information to support PWCC's request for final release of reclamation liability on approximately 2,981 acres of Initial Program mined lands in the J-1, N-6, J-16, and N-14 mining areas at the Kayenta Complex (Maps 1.1.A and 1.1.B). The reclaimed areas are subject to the performance standards and liability release criteria of 30 CFR, 715, Subpart B regulations because they were disturbed on or after December 16, 1977 and prior to issuance of the Permanent Program Permits pursuant to the 30 CFR, Part 750 regulations. This reclamation liability release application (RLRA) also addresses the OSMRE checklist for Initial Lands Release Application and OSMRE's Guidance for Initial Program Termination of SMCRA Jurisdiction, (OSMRE, July 1997). The checklist and guidance document were used as guides to prepare this application, insofar as items in these documents apply to areas subject to 30 CFR 715, Subpart B.

Upon approval of this release application, PWCC intends to make the subject lands available for use by the Navajo Nation. PWCC no longer requires exclusive use of the J-1, N-6, J-16, and N-14 reseeded mined lands; thus, local residents may once again use them. By relinquishing its exclusive use, PWCC is not surrendering and terminating the coal leases as to these seeded lands. To do so would create administrative and logistical problems, since these lands are near mining facilities and active mining areas. Although the surface mineable coal has been removed from the subject lands, their proximity to the mining activities and the possibility that future use of a portion of the lands may be necessary thus requiring PWCC to maintain its lease rights on these lands. Future uses could include such things as pipelines, powerlines, access roads, or other mining facilities. These future activities will be permitted and approved by OSMRE prior to construction of these support facilities. Therefore, this application approval will also complete the reclamation liability requirements in PWCC’s coal leases.

The major subjects addressed herein include pre and postmining topography (Tab 2), protection of the hydrologic balance (Tab 3), minesoil reconstruction (Tab 4), revegetation (Tab 5), and permanent facilities (Tab 6). The information presented with each tab clearly indicates that PWCC has successfully reclaimed the J-1, N-6, J-16, and N-14 release parcels. In addition, over the last thirty years or more, OSMRE and Navajo Nation Tribal Inspectors have made regular site inspections of the J-1, N-6, J-16, and N-14 areas, including complete quarterly and partial inspections during each year. Backfilling and grading, and minesoil reconstruction have been accomplished such that a stable landform has been created which reasonably approximates the premining contour. Impacts to the prevailing hydrologic balance have been minimized. A diverse, effective, and permanent vegetation cover has been established which meets the vegetation cover standard and provides exceptional utility for the postmining rangeland land use. Tab 6, Permanent Facilities, identifies the facilities that are proposed for retention in the postmining landscape to facilitate and enhance the postmining land use.



Peabody

Kayenta Complex
PO Box 650
Kayenta, Arizona USA 86033

Map 1.1.A
J-1 and N-6
Termination of Jurisdiction Reclamation Liability Release Area

Produced by
Gary Altsisi
Professional
Engineer

August 2, 2019
Revision

1 inch = 600 feet

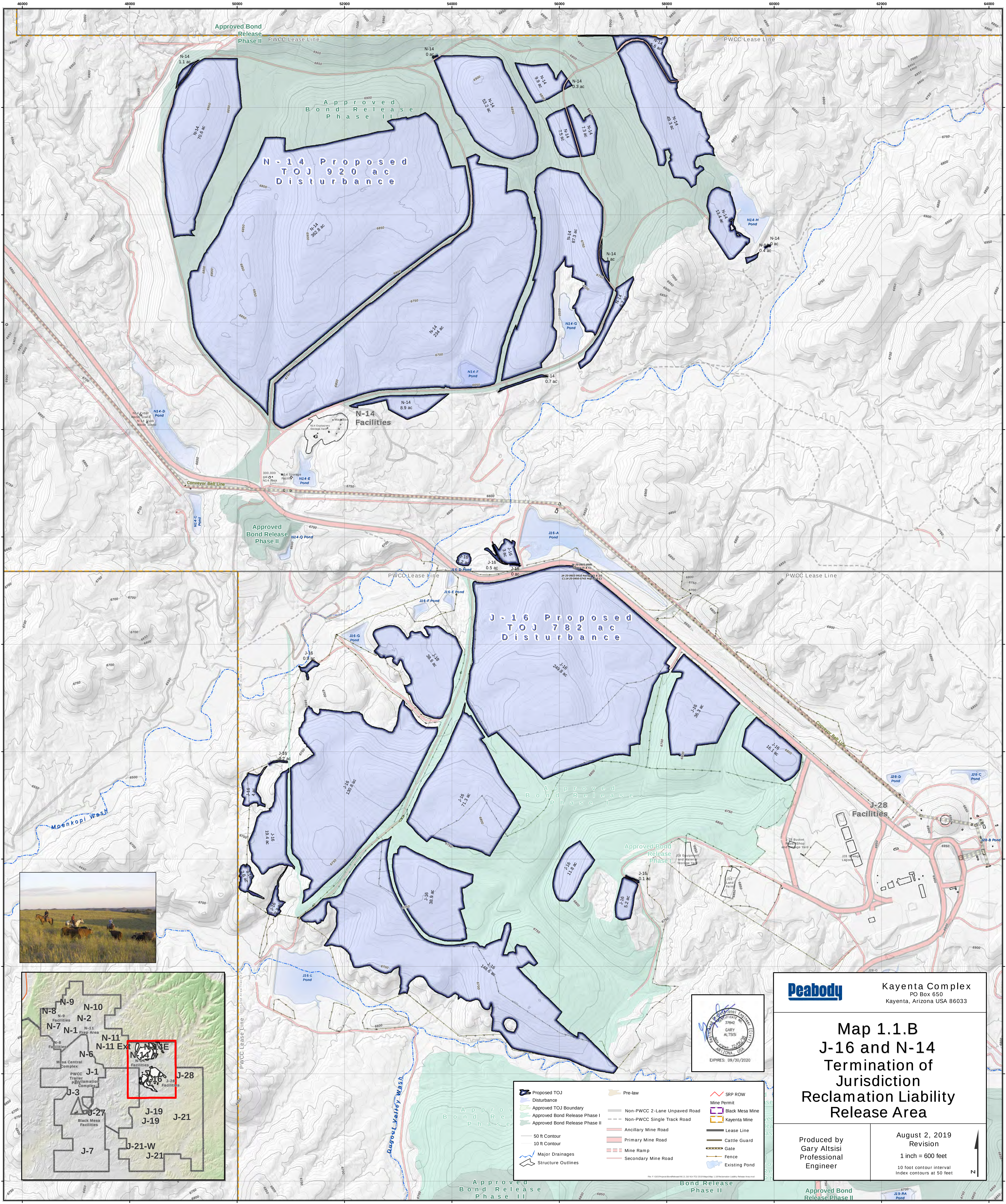
10 foot contour interval
Index contours at 50 feet

N

Registered Professional Engineer (Civil)
Certificate No. 37842
GARY ALTSISI
Date signed: 12/05/18
ARIZONA, USA
EXPIRES: 09/30/2020

Proposed TOJ
Disturbance
Approved TOJ Boundary
Approved Bond Release Phase I
Approved Bond Release Phase II
50 ft Contour
10 ft Contour
Major Drainages
Structure Outlines
Pre-law
Non-PWCC 2-Lane Unpaved Road
Non-PWCC Single Track Road
Ancillary Mine Road
Primary Mine Road
Mine Ramp
Secondary Mine Road
SRP ROW
Mine Permit
Black Mesa Mine
Kayenta Mine
Lease Line
Cattle Guard
Gate
Fence
Existing Pond

File: F:\GIS\Projects\BondRelease\N6 J1 J16 N14 TOJ 2019\Maps\Map 1.1A Reclamation Liability Release Area.mxd



Kayenta Complex
PO Box 650
Kayenta, Arizona USA 86033

Map 1.1.B
J-16 and N-14
Termination of Jurisdiction Reclamation Liability Release Area

Produced by
Gary Altsisi
Professional
Engineer

August 2, 2019
Revision

1 inch = 600 feet

10 foot contour interval
Index contours at 50 feet

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37842
GARY ALTSISI
12/05/18
EXPIRES: 09/30/2020

▨	Proposed TOJ
▨	Disturbance
▨	Approved TOJ Boundary
▨	Approved Bond Release Phase I
▨	Approved Bond Release Phase II
—	50 ft Contour
—	10 ft Contour
—	Major Drainages
—	Structure Outlines
▨	Pre-law
—	Non-PWCC 2-Lane Unpaved Road
- - -	Non-PWCC Single Track Road
—	Ancillary Mine Road
—	Primary Mine Road
- - -	Mine Ramp
—	Secondary Mine Road
—	SRP ROW
	Mine Permit
☐	Black Mesa Mine
☐	Kayenta Mine
—	Lease Line
—	Cattle Guard
—	Gate
—×—	Fence
▨	Existing Pond

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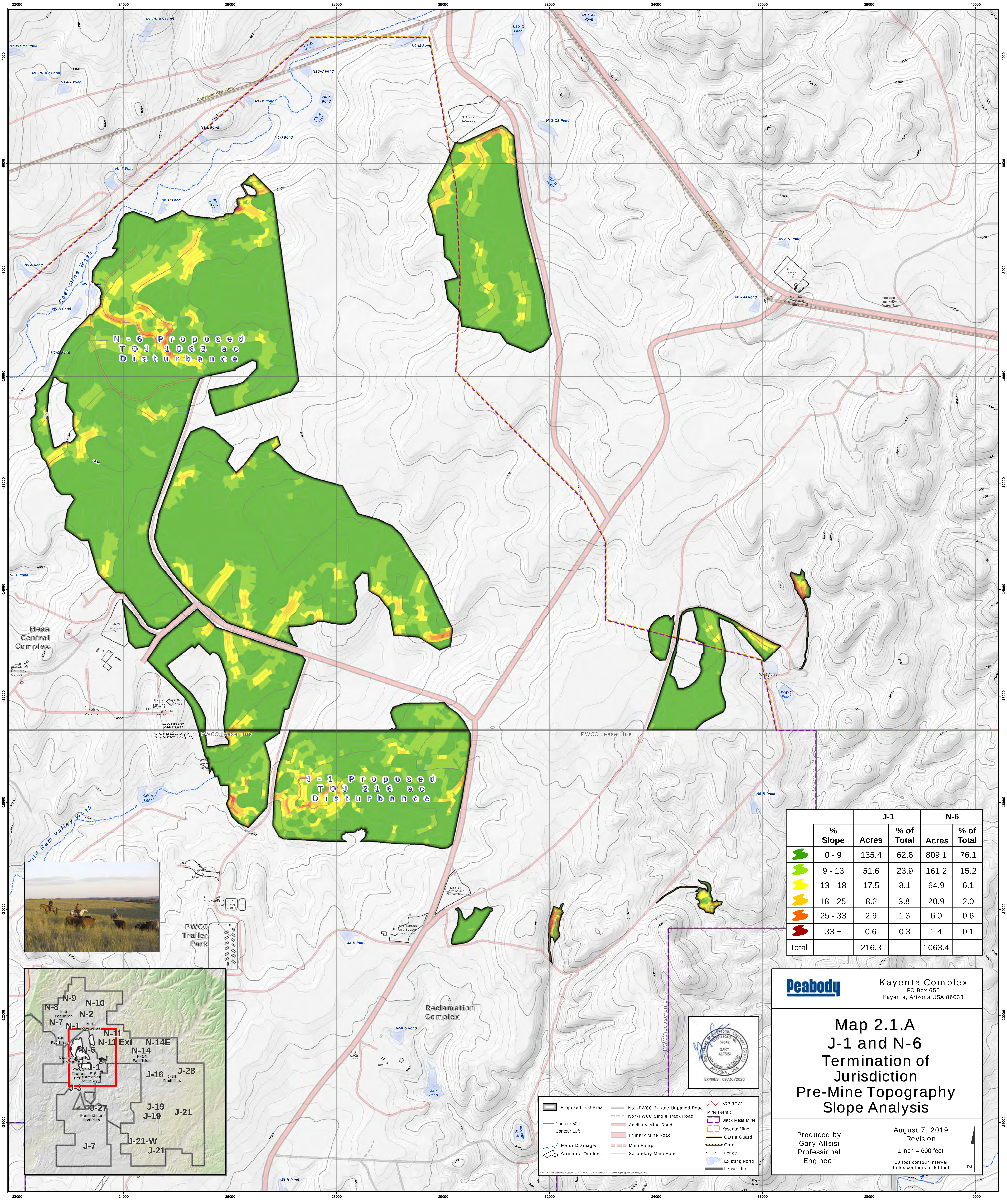

		J-1		N-6	
	% Slope	Acres	% of Total	Acres	% of Total
🟩	0 - 9	135.4	62.6	809.1	76.1
🟩	9 - 13	51.6	23.9	161.2	15.2
🟨	13 - 18	17.5	8.1	64.9	6.1
🟨	18 - 25	8.2	3.8	20.9	2.0
🟧	25 - 33	2.9	1.3	6.0	0.6
🟥	33 +	0.6	0.3	1.4	0.1
Total		216.3		1063.4	

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Kayenta Complex
PO Box 650
Kayenta, Arizona USA 86033

Map 2.1.A
J-1 and N-6
Termination of Jurisdiction
Pre-Mine Topography Slope Analysis

Produced by
Gary Altsisi
Professional
Engineer

August 7, 2019
Revision

1 inch = 600 feet

10 foot contour interval
Index contours at 50 feet

N

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12/05/18
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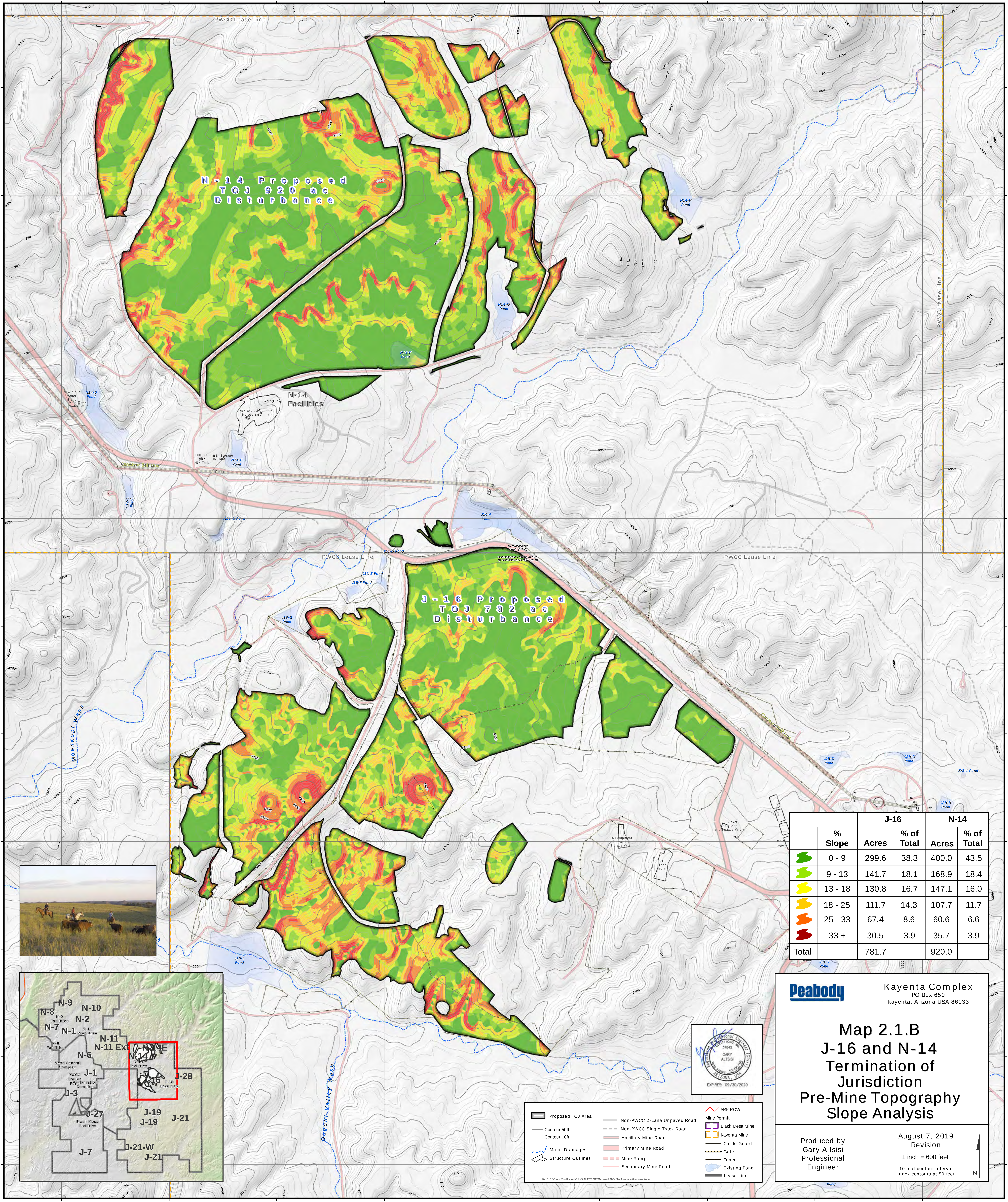

File: F:\GIS\Projects\BondRelease\N6 J1 J16 N14 TOJ 2019\Maps\Map 2.1B PreMine Topography Slope Analysis.mxd

		J-16		N-14	
	% Slope	Acres	% of Total	Acres	% of Total
🟩	0 - 9	299.6	38.3	400.0	43.5
🟩	9 - 13	141.7	18.1	168.9	18.4
🟨	13 - 18	130.8	16.7	147.1	16.0
🟨	18 - 25	111.7	14.3	107.7	11.7
🟧	25 - 33	67.4	8.6	60.6	6.6
🟥	33 +	30.5	3.9	35.7	3.9
Total		781.7		920.0	

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Kayenta Complex
PO Box 650
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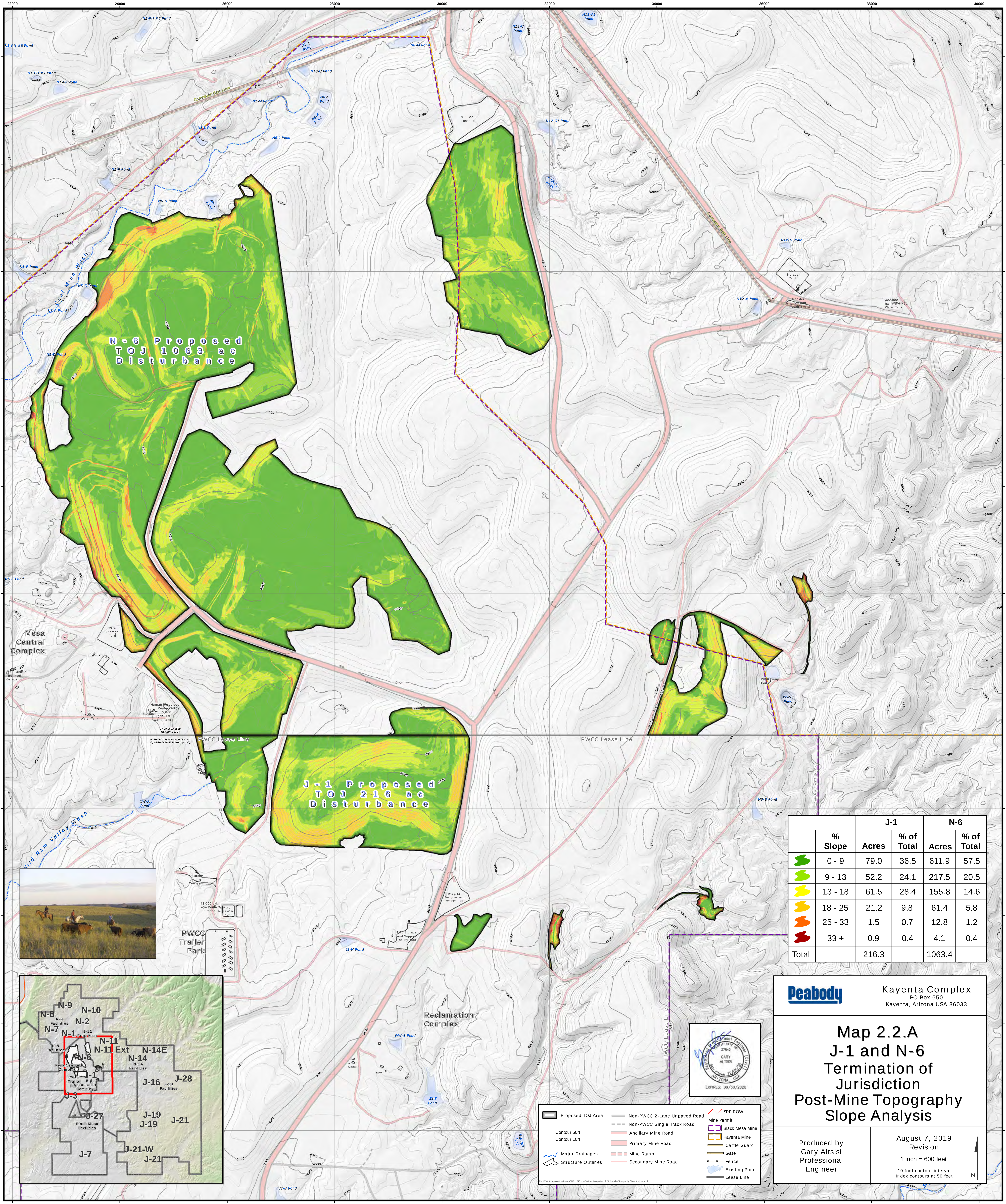
Map 2.1.B
J-16 and N-14
Termination of Jurisdiction
Pre-Mine Topography
Slope Analysis

Produced by
Gary Altsisi
Professional
Engineer

August 7, 2019
Revision

1 inch = 600 feet

10 foot contour interval
Index contours at 50 feet



		J-1		N-6	
	% Slope	Acres	% of Total	Acres	% of Total
🟩	0 - 9	79.0	36.5	611.9	57.5
🟩	9 - 13	52.2	24.1	217.5	20.5
🟨	13 - 18	61.5	28.4	155.8	14.6
🟧	18 - 25	21.2	9.8	61.4	5.8
🟧	25 - 33	1.5	0.7	12.8	1.2
🟥	33 +	0.9	0.4	4.1	0.4
Total		216.3		1063.4	

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ARIZONA, USA
EXPIRES: 09/30/2020

Kayenta Complex
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Kayenta, Arizona USA 86033

Map 2.2.A
J-1 and N-6
Termination of Jurisdiction
Post-Mine Topography Slope Analysis

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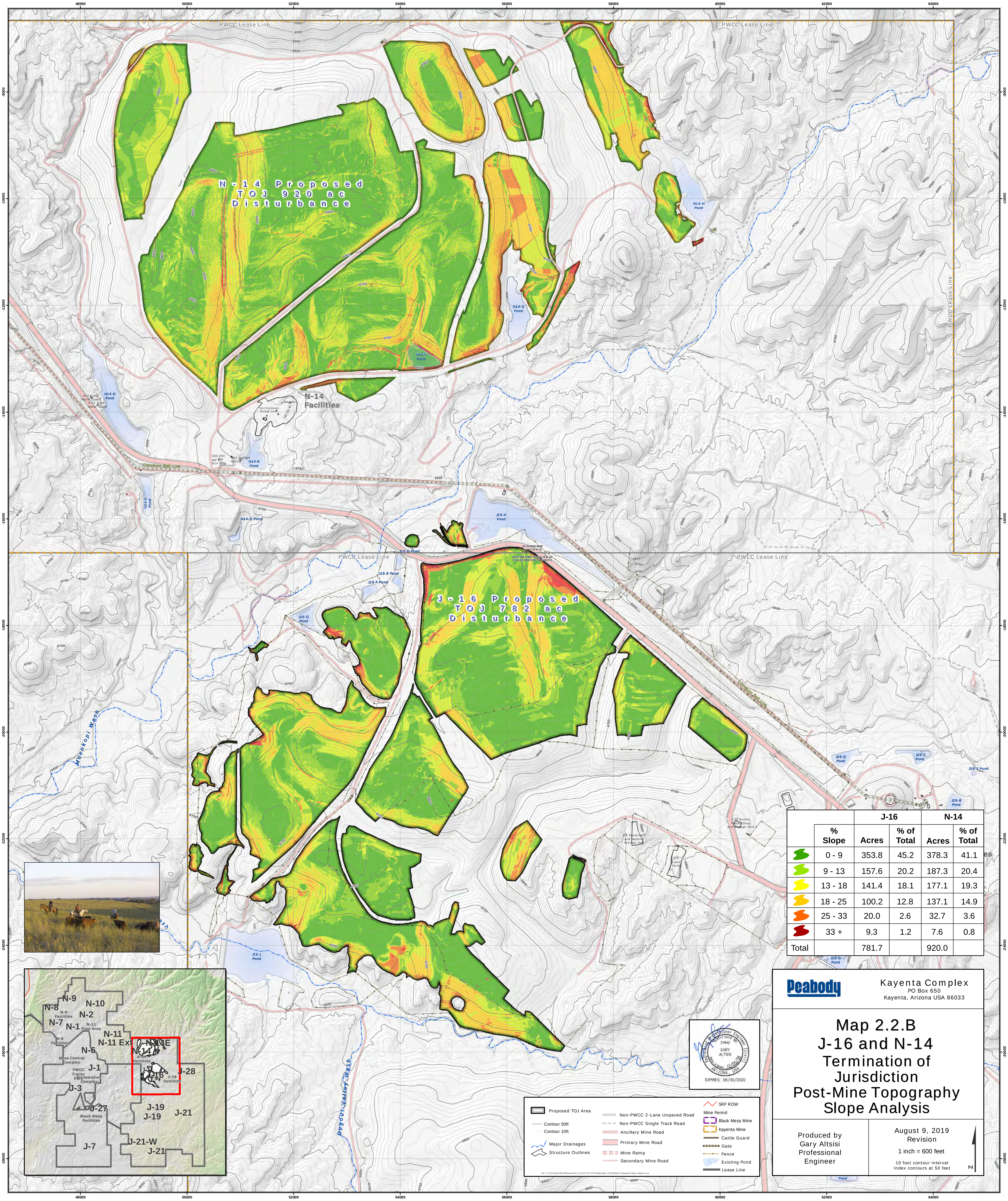
Professional
Engineer

August 7, 2019
Revision

1 inch = 600 feet

10 foot contour interval
Index contours at 50 feet

N



		J-16		N-14	
	% Slope	Acres	% of Total	Acres	% of Total
🟩	0 - 9	353.8	45.2	378.3	41.1
🟩	9 - 13	157.6	20.2	187.3	20.4
🟨	13 - 18	141.4	18.1	177.1	19.3
🟨	18 - 25	100.2	12.8	137.1	14.9
🟧	25 - 33	20.0	2.6	32.7	3.6
🟥	33 +	9.3	1.2	7.6	0.8
Total		781.7		920.0	

Peabody

Kayenta Complex
PO Box 650
Kayenta, Arizona USA 86033

Map 2.2.B
J-16 and N-14
Termination of Jurisdiction
Post-Mine Topography
Slope Analysis

Produced by
Gary Altsisi
Professional
Engineer

August 9, 2019
Revision

1 inch = 600 feet

10 foot contour interval
Index contours at 50 feet

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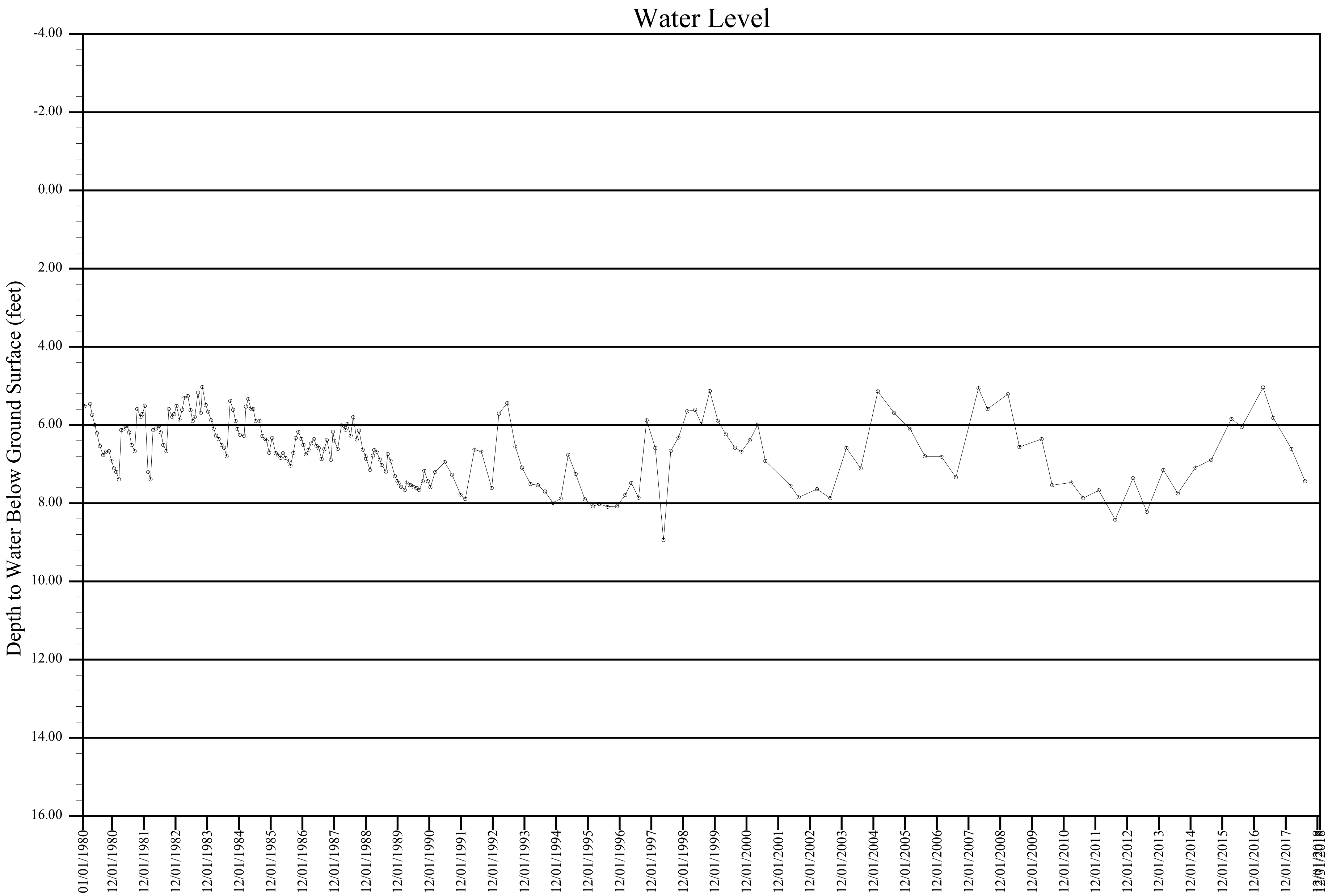
GARY ALTSISI
Date signed: 12/05/18
ARIZONA, USA
EXPIRES: 09/30/2020

File: F:\GIS\Projects\BondRelease\N6 J1 J16 N14 TOJ 2019\Maps\Map 2.2B PostMine Topography Slope Analysis.mxd

Attachment 3-1a

Water Level Hydrographs for Alluvial Wells Proximate to the J-1/N-6, J-16 and N-14 TOJ Parcels


Water Level
Depth to Water Below Ground Surface (feet)
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-2.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
16.00
01/01/1980
12/01/1980
12/01/1981
12/01/1982
12/01/1983
12/01/1984
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12/01/2012
12/01/2013
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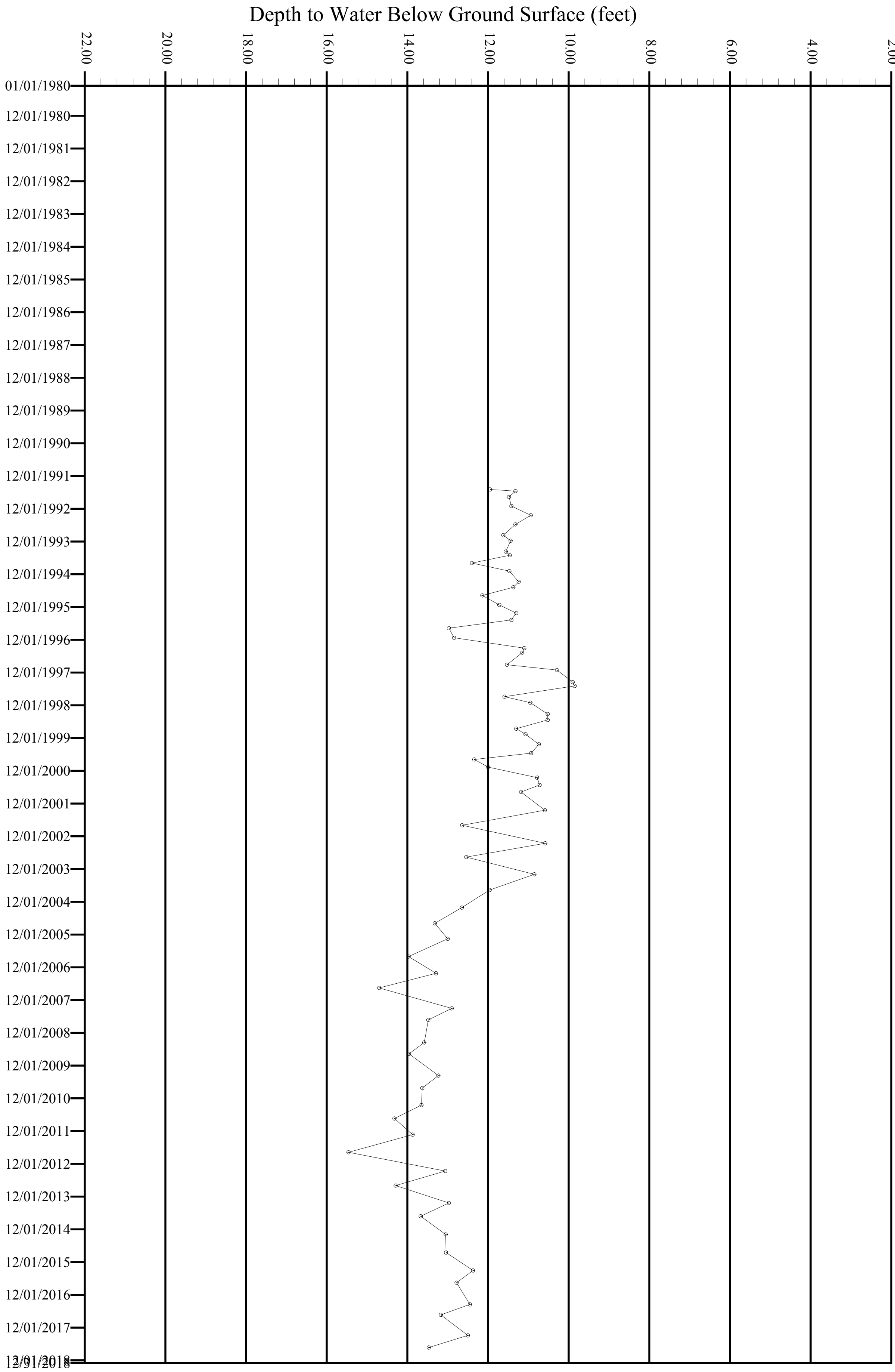
12/01/2017
12/01/2018
12/31/2018

ALUV17

Water Level

ALUV193



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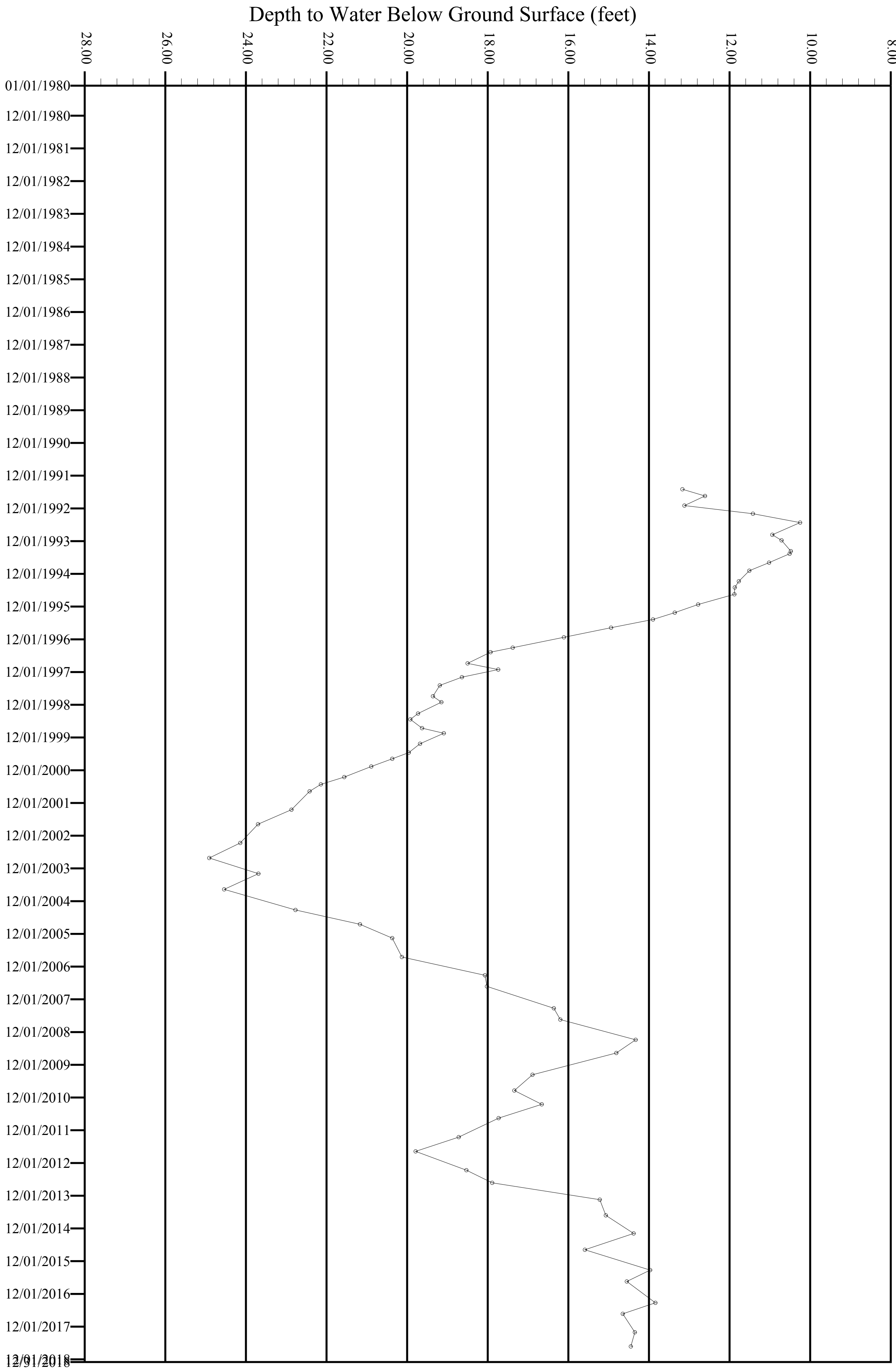
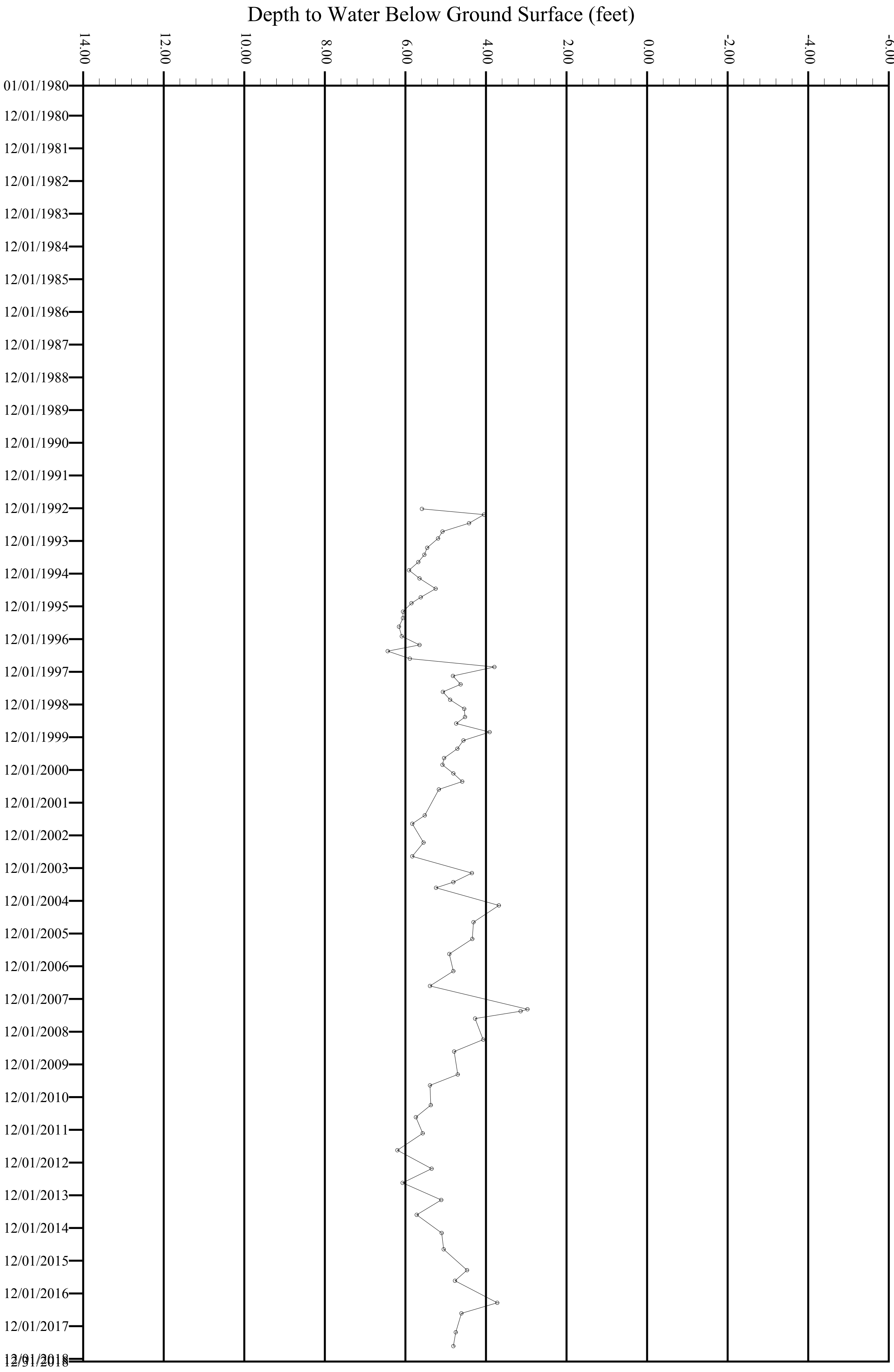
Water Level



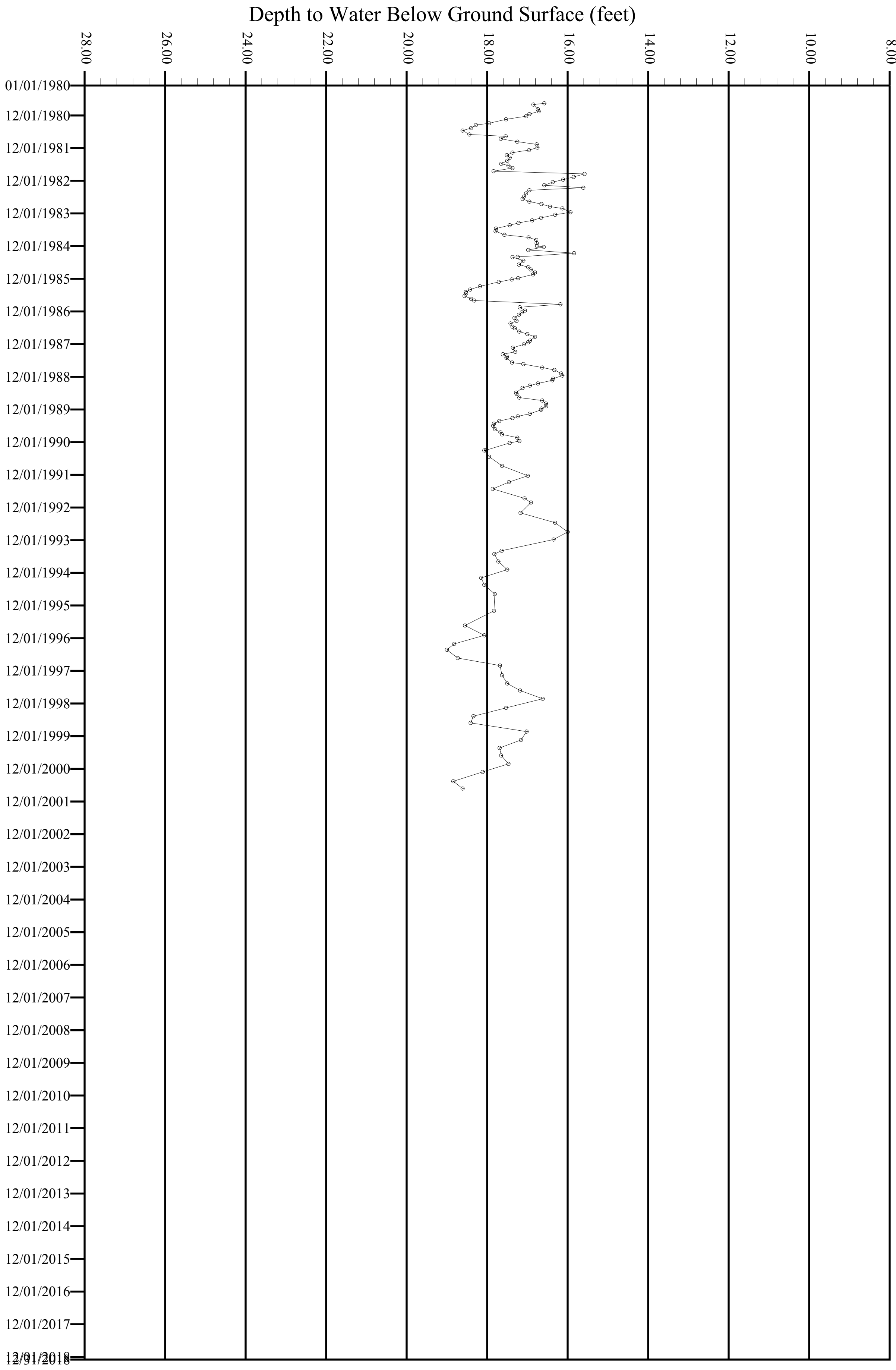
Water Level

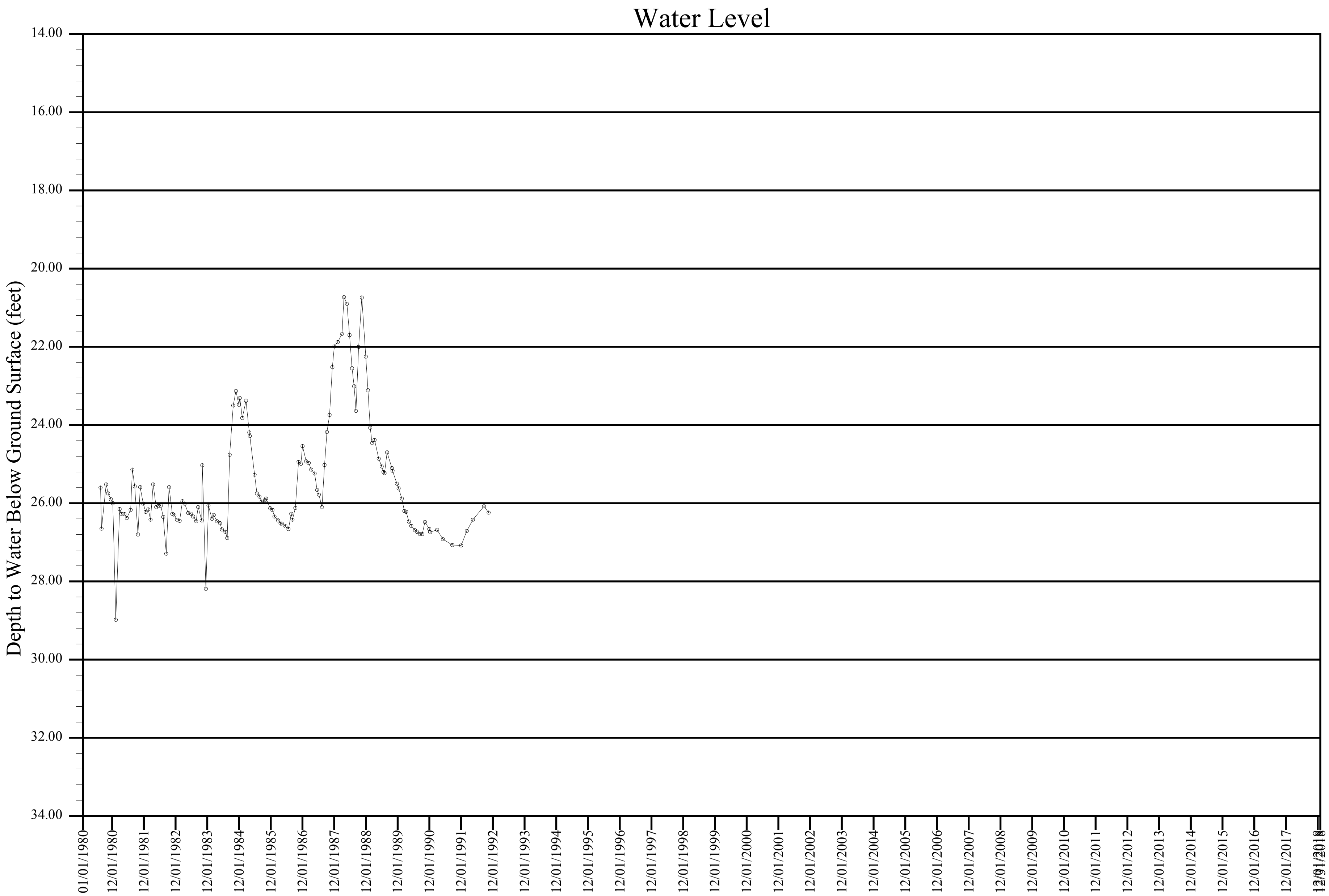
ALUV200



Water Level

ALUV23




Water Level
Depth to Water Below Ground Surface (feet)
14.00
16.00
18.00
20.00
22.00
24.00
26.00
28.00
30.00
32.00
34.00
01/01/1980
12/01/1980
12/01/1981
12/01/1982
12/01/1983
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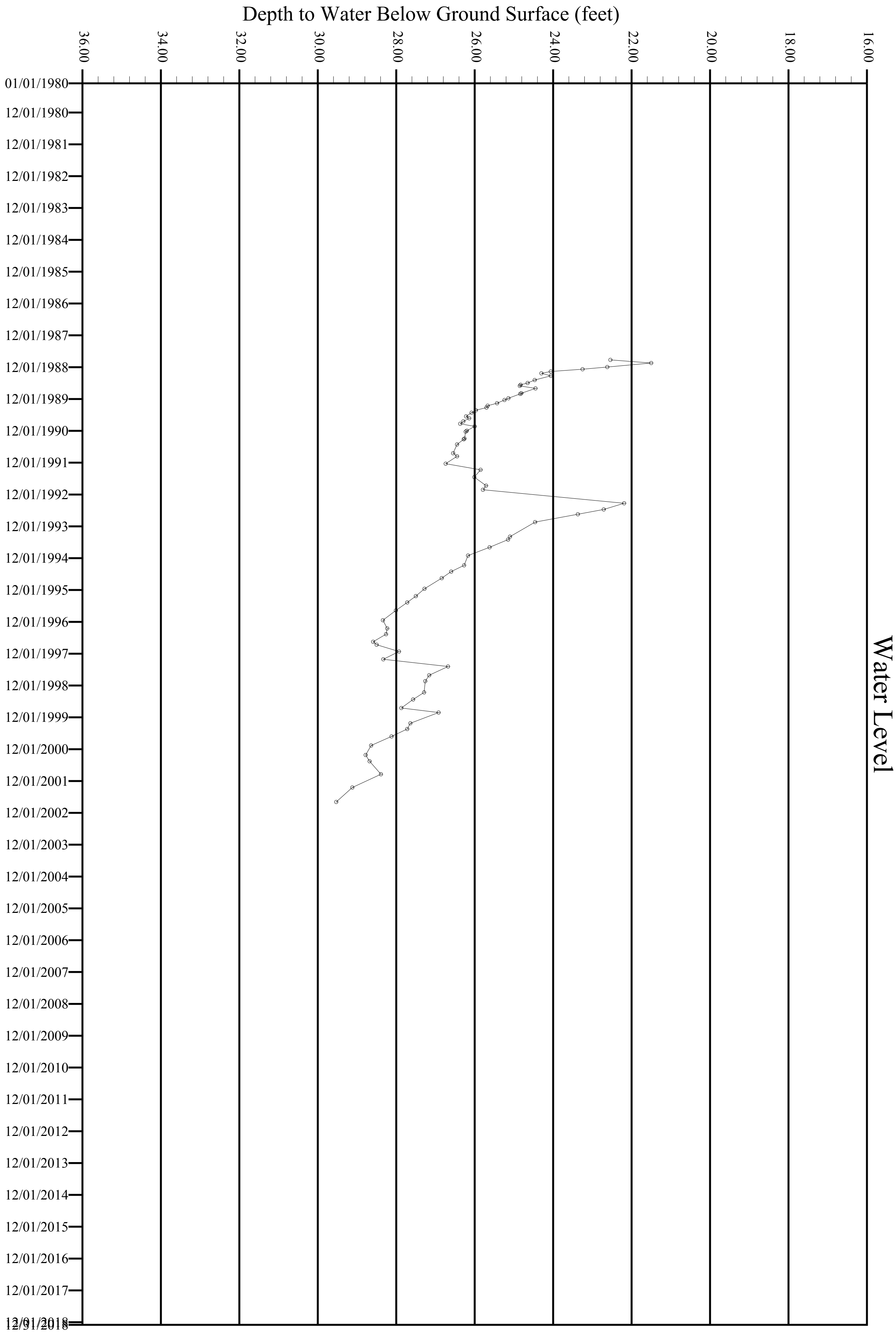
12/01/2018
12/31/2018

ALUV27

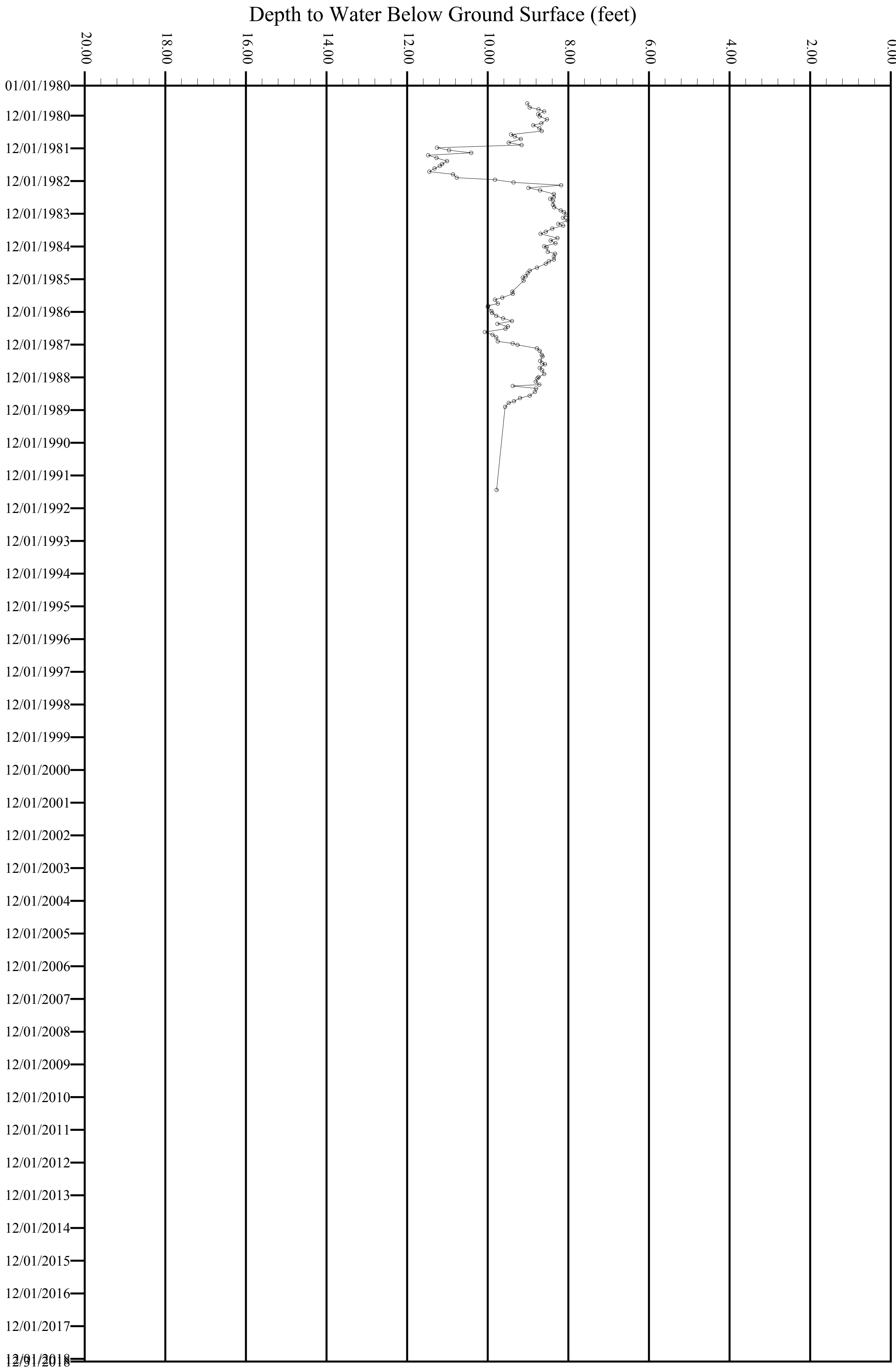
Water Level

ALUV27R



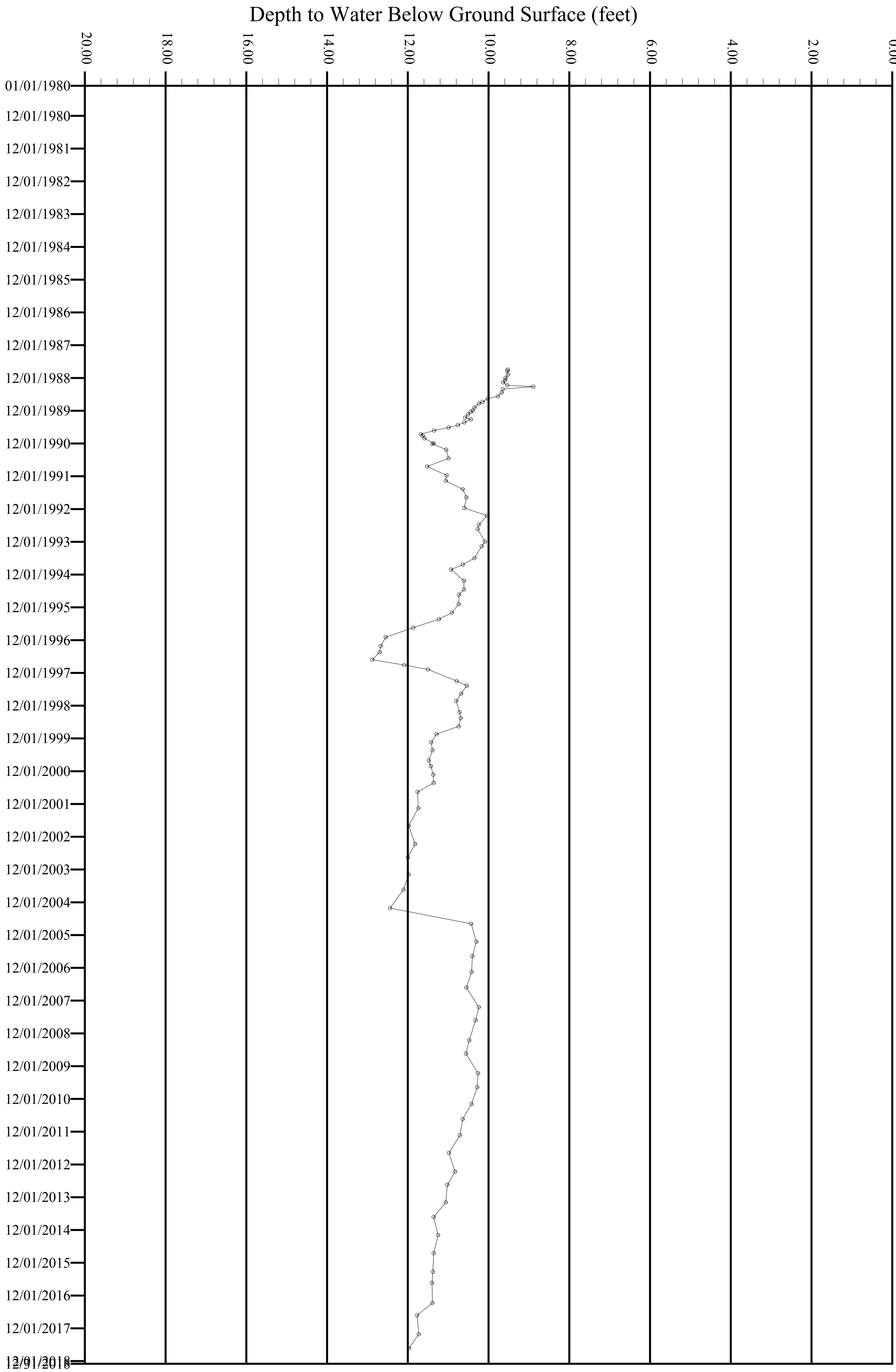
Water Level

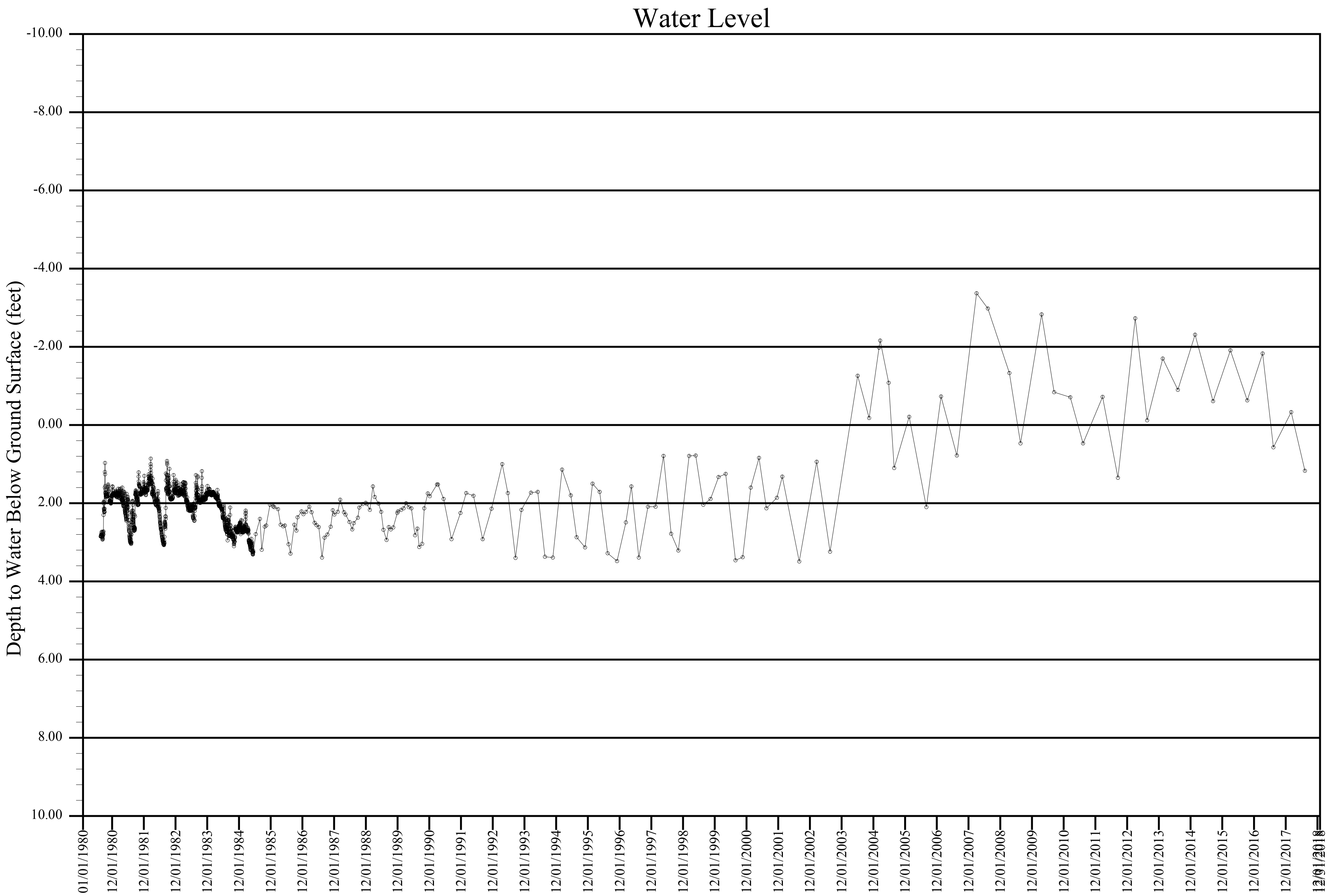
ALUV80



Water Level

ALUV80R




Water Level
Depth to Water Below Ground Surface (feet)
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-6.00
-4.00
-2.00
0.00
2.00
4.00
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8.00
10.00
01/01/1980
12/01/1980
12/01/1981
12/01/1982
12/01/1983
12/01/1984
12/01/1985
12/01/1986
12/01/1987
12/01/1988
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12/01/2010
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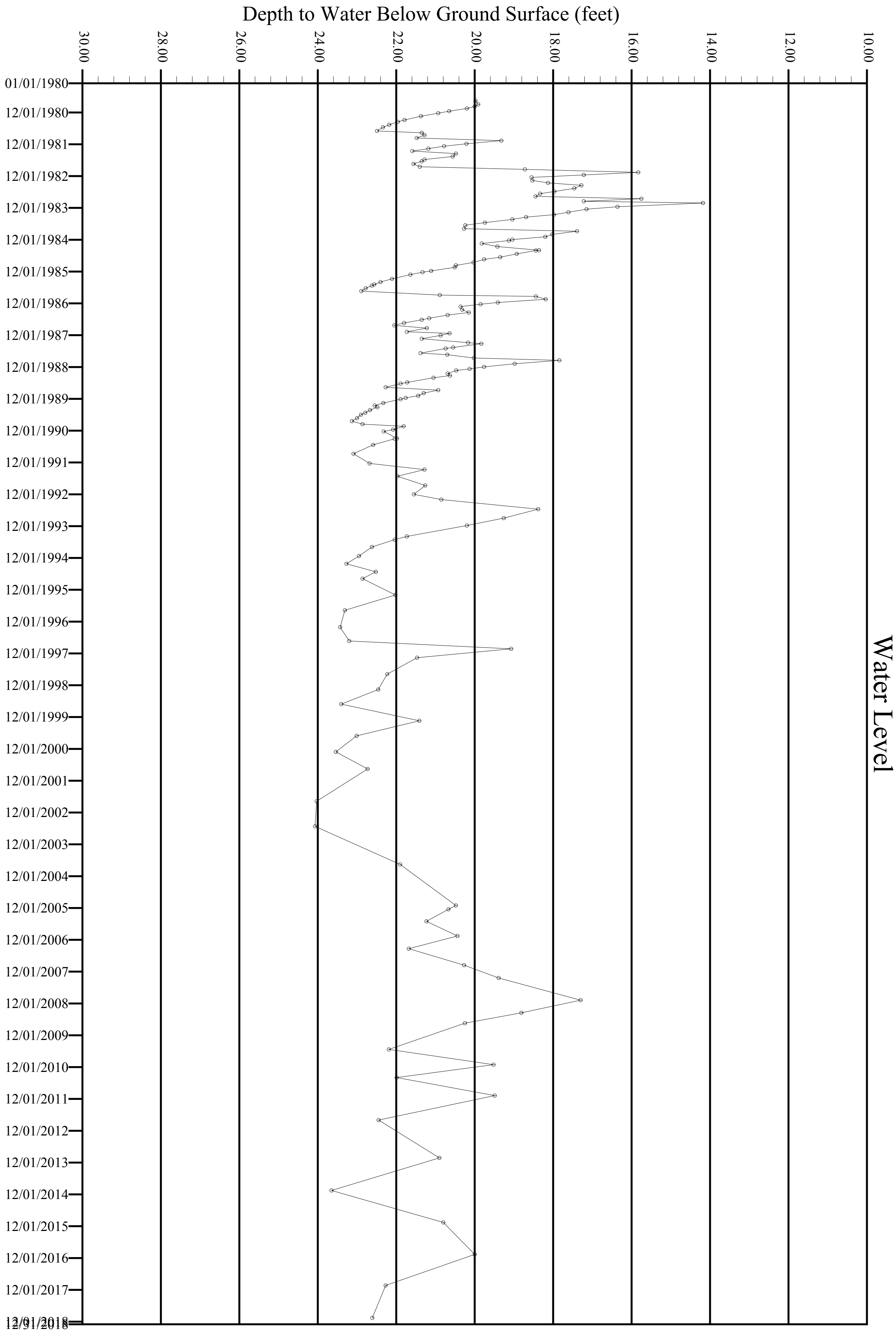
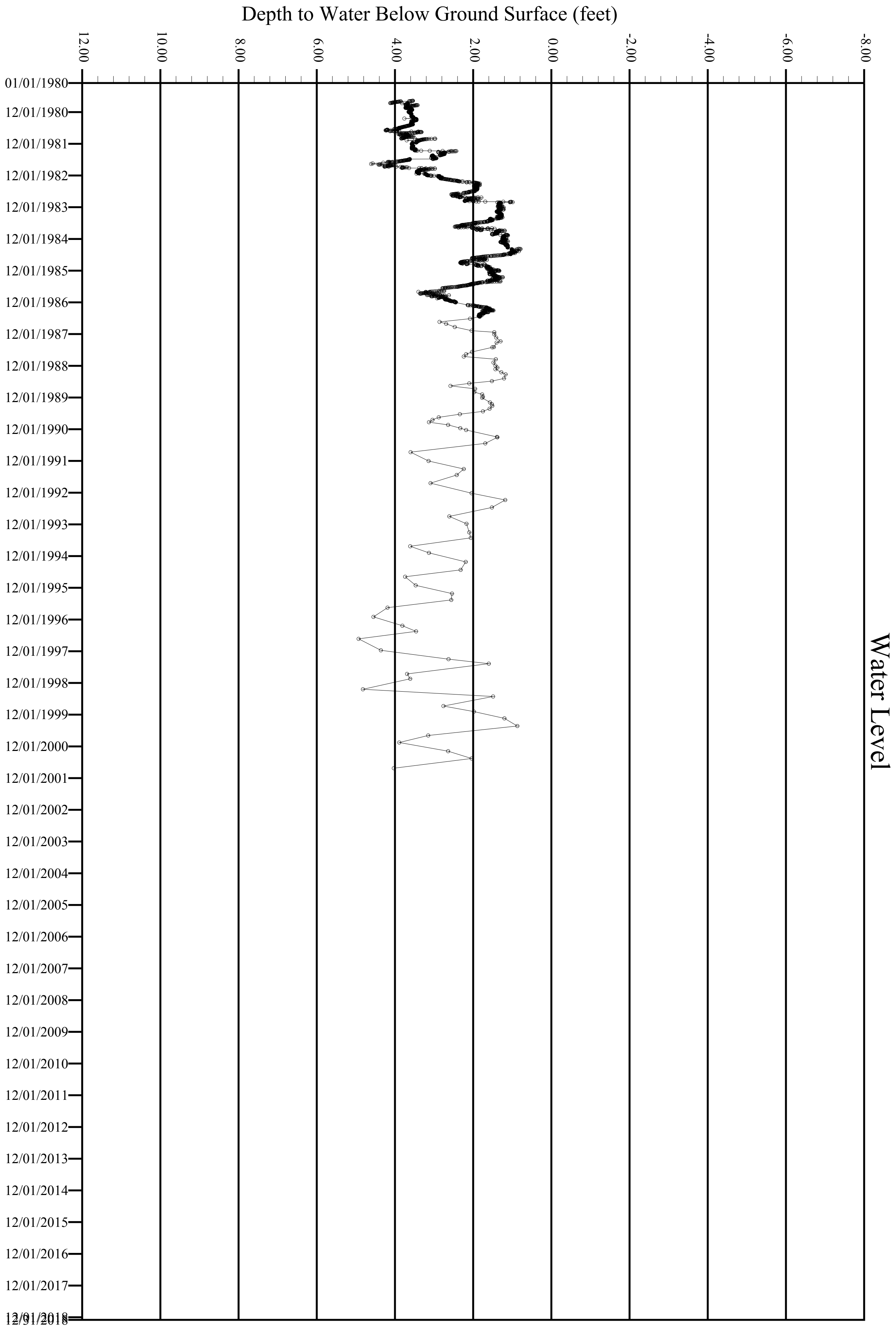
12/31/2018

ALUV83

Water Level

ALUV87





Depth to Water Below Ground Surface (feet)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
01/01/1980
12/01/1980
12/01/1981
12/01/1982
12/01/1983
12/01/1984
12/01/1985
12/01/1986
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12/01/1988
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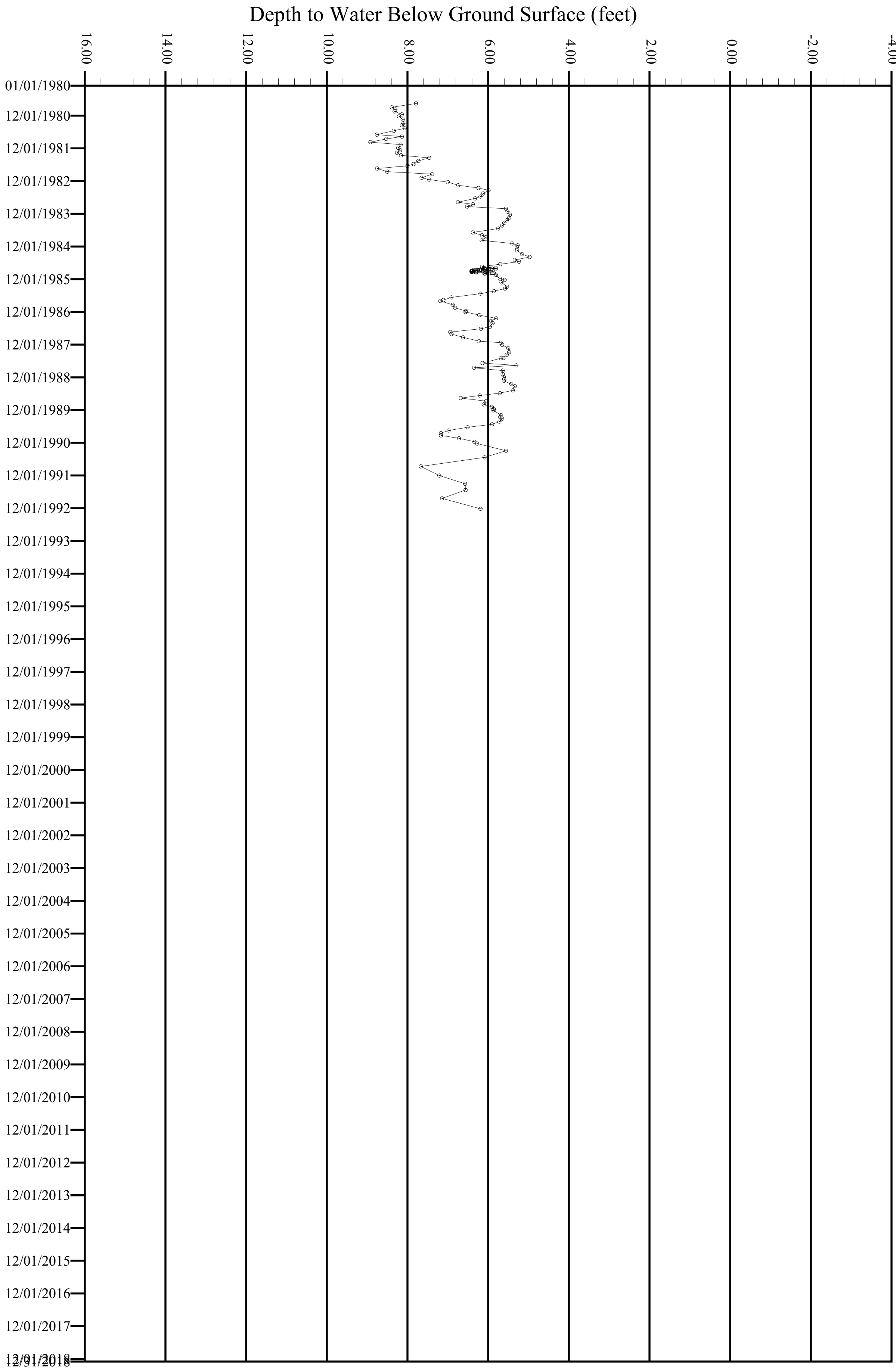
12/01/2000
12/01/2001
12/01/2002
12/01/2003
12/01/2004
12/01/2005
12/01/2006
12/01/2007
12/01/2008
12/01/2009
12/01/2010
12/01/2011
12/01/2012
12/01/2013
12/01/2014
12/01/2015
12/01/2016
12/01/2017
12/01/2018
12/31/2018
Water Level

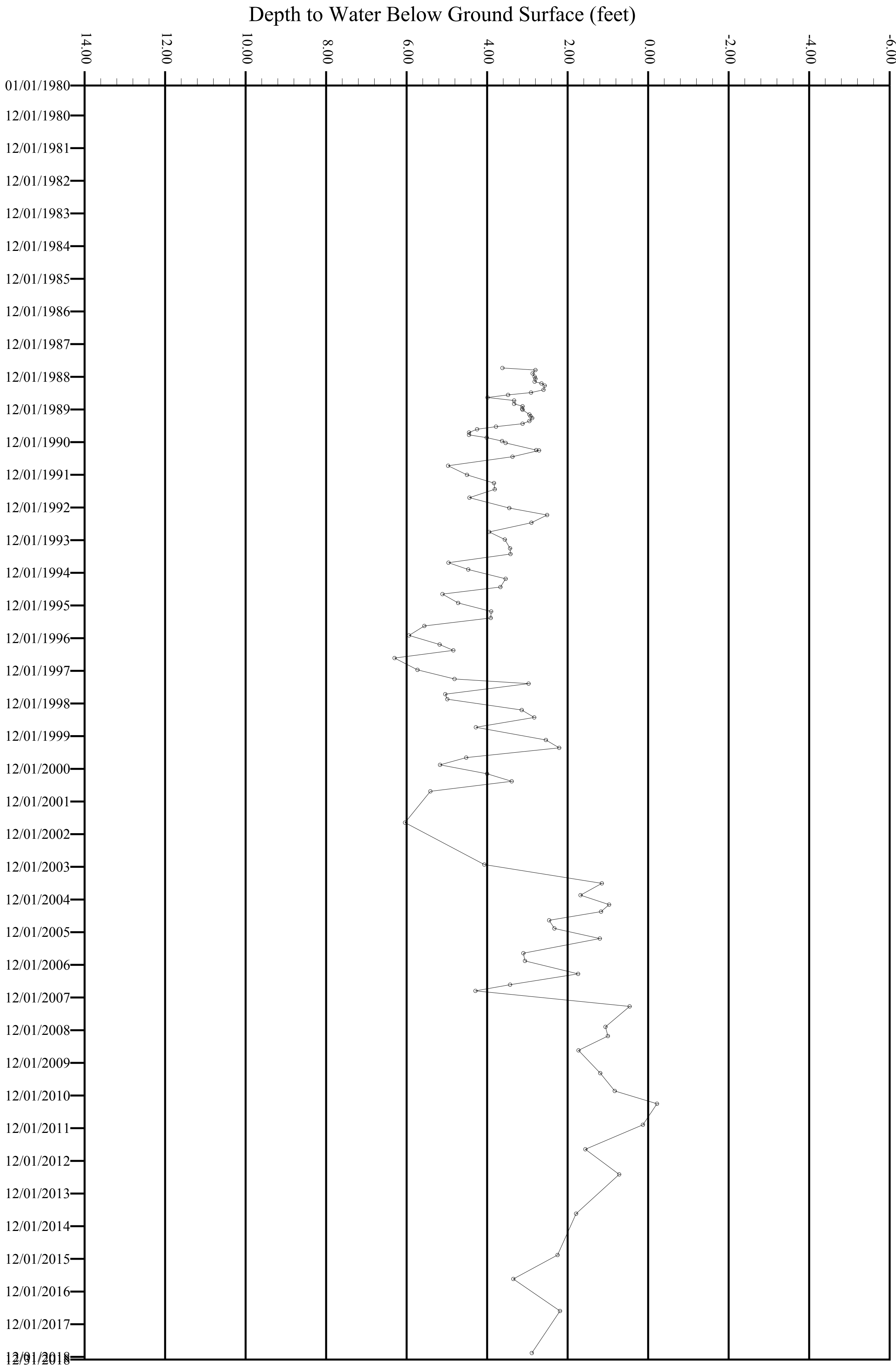
ALUV88

Water Level

ALUV89



Water Level

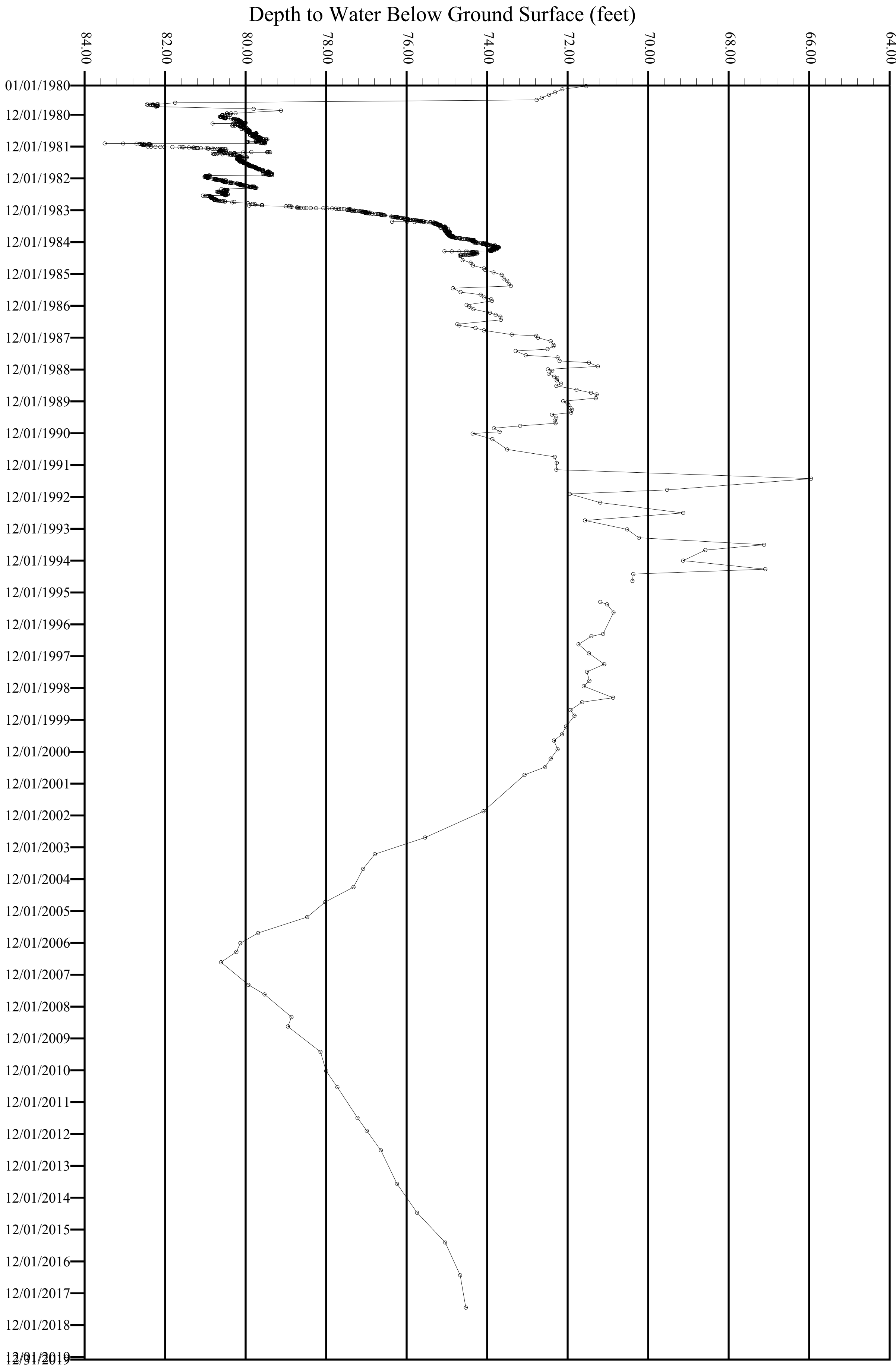


ALUV89R

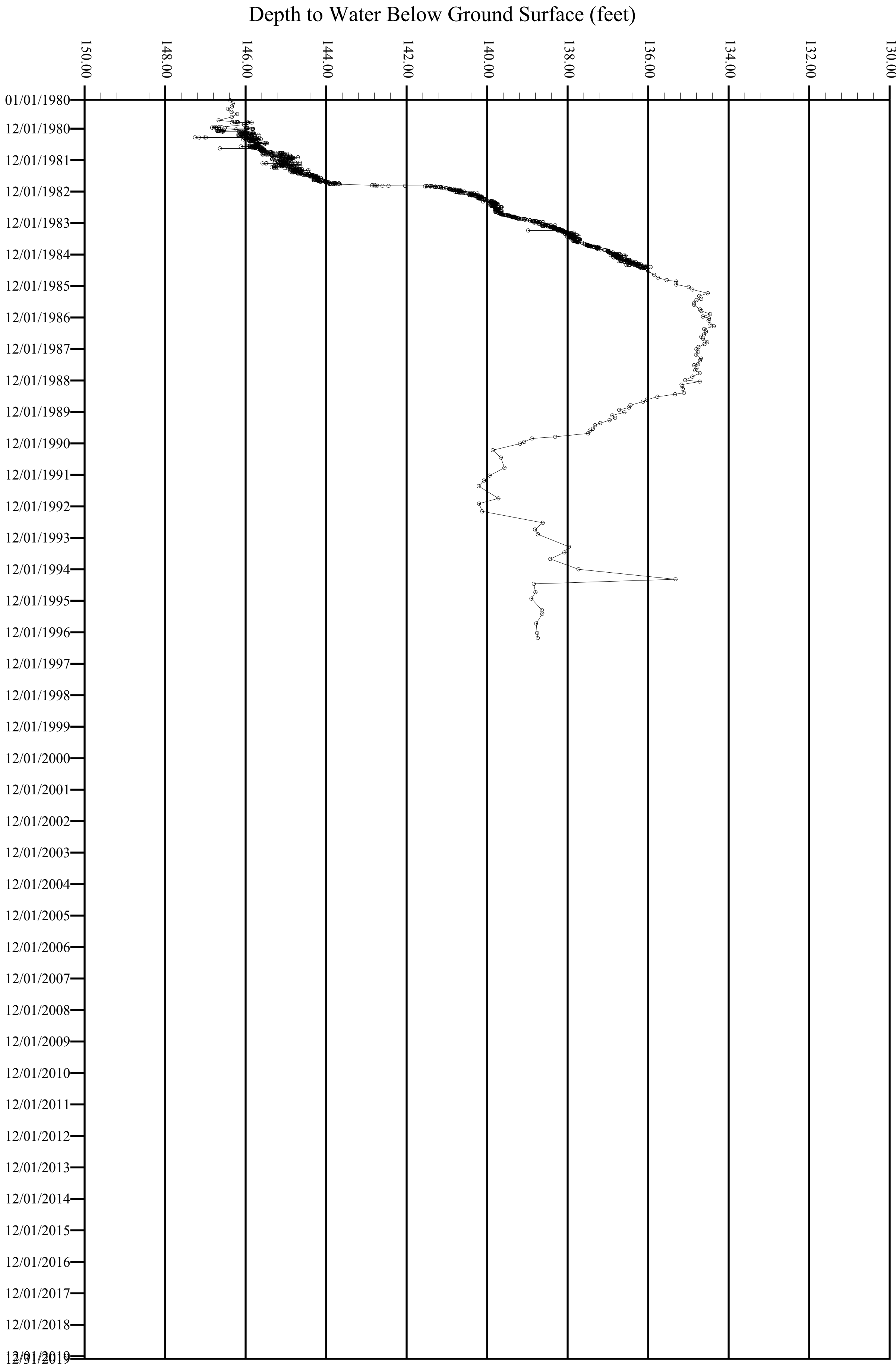
Attachment 3-1b

Water Level Hydrographs for Wepo Wells
Proximate to the J-1/N-6, J-16 and N-14 TOJ Parcels

Water Level



WEPO40

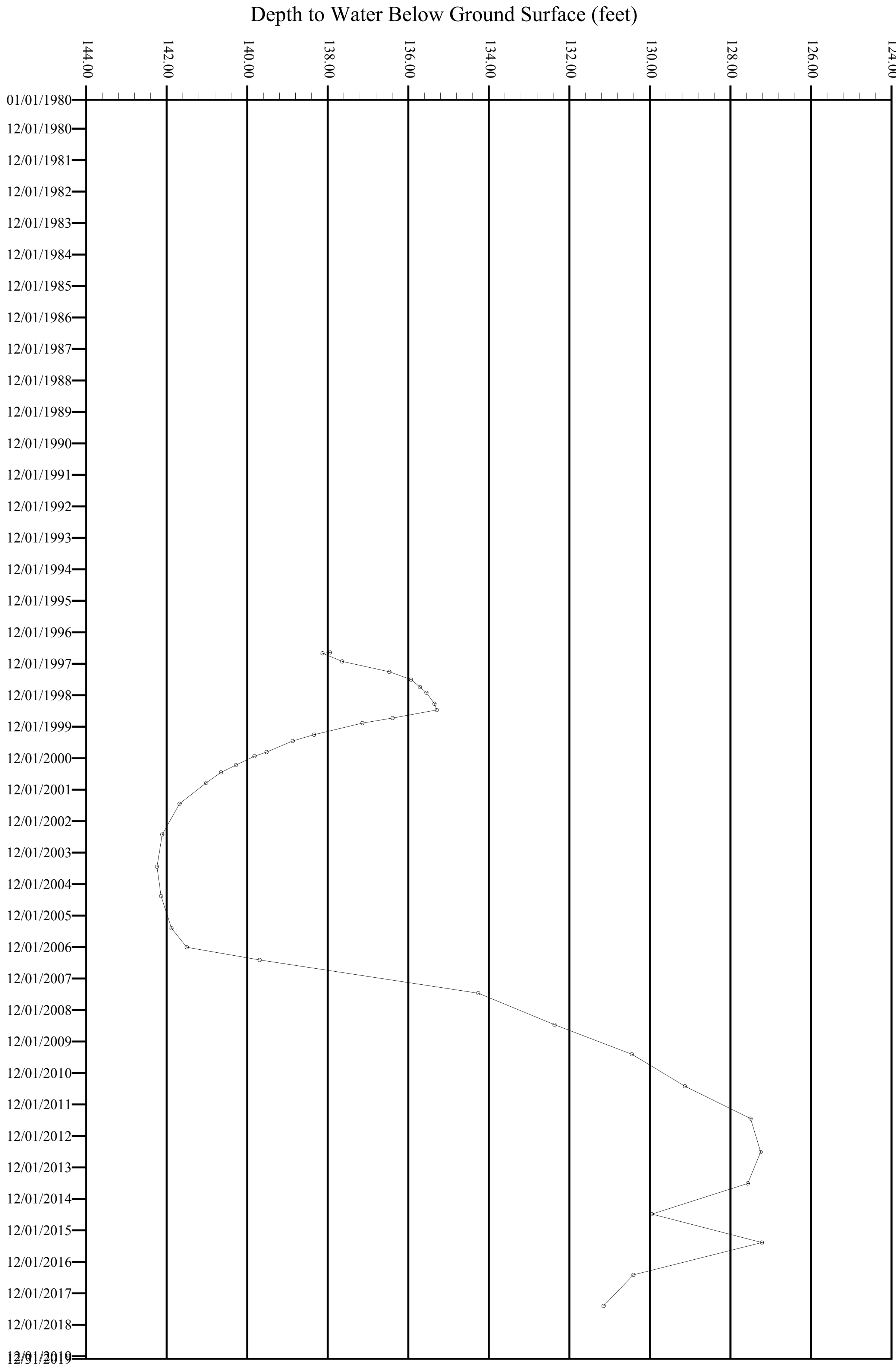


Water Level

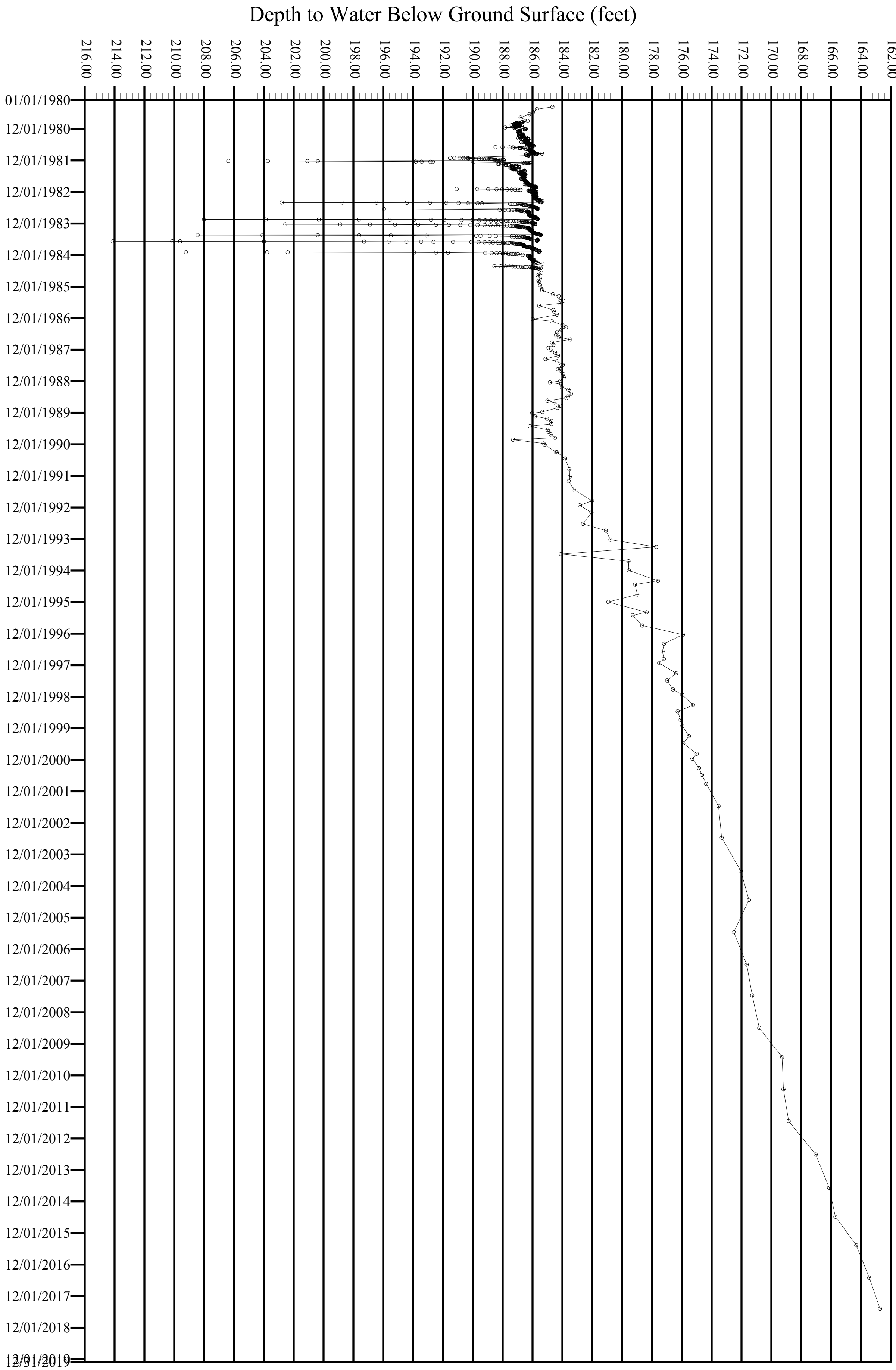
WEPO43

WEPO43R

Water Level



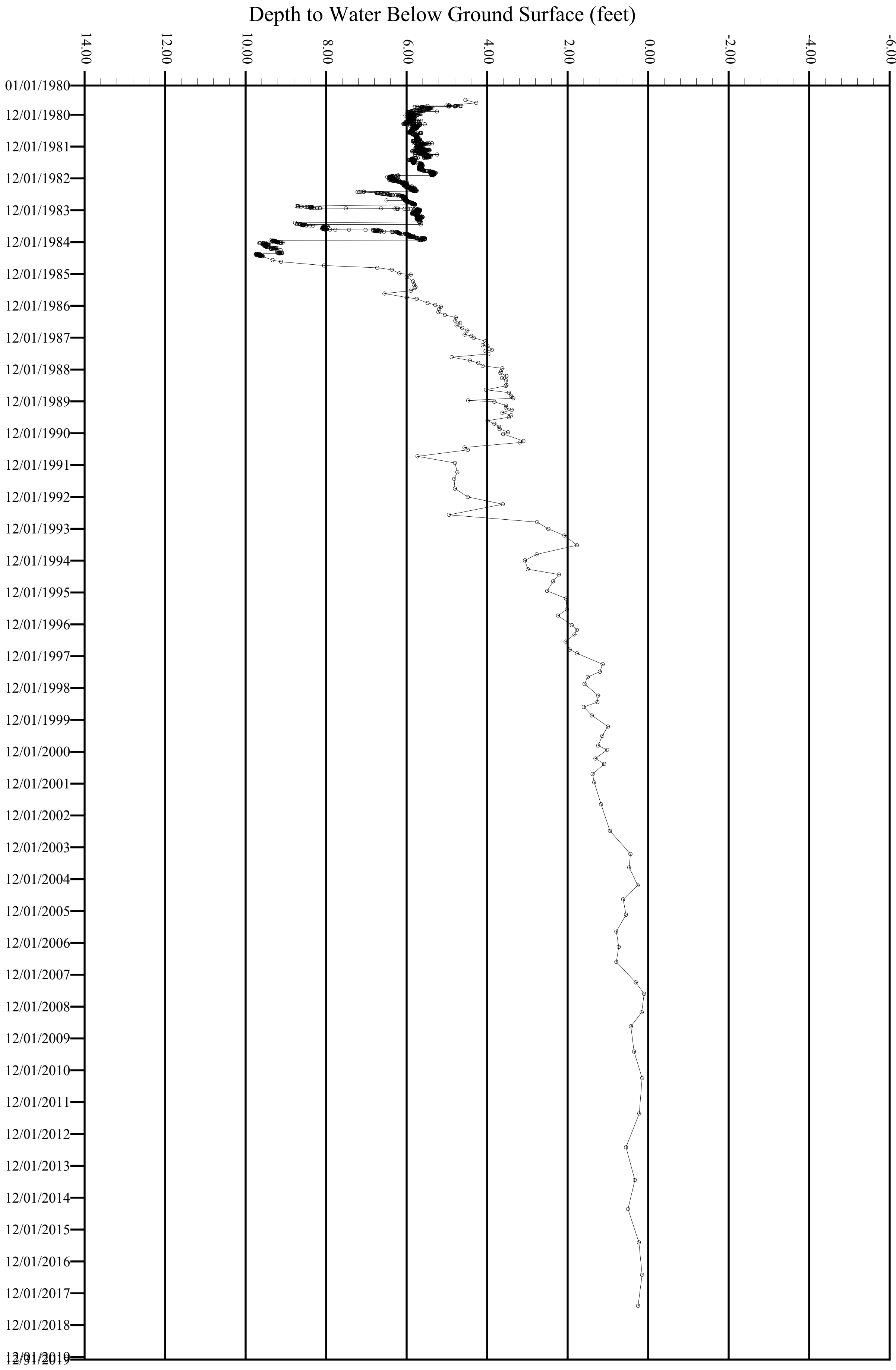
Water Level



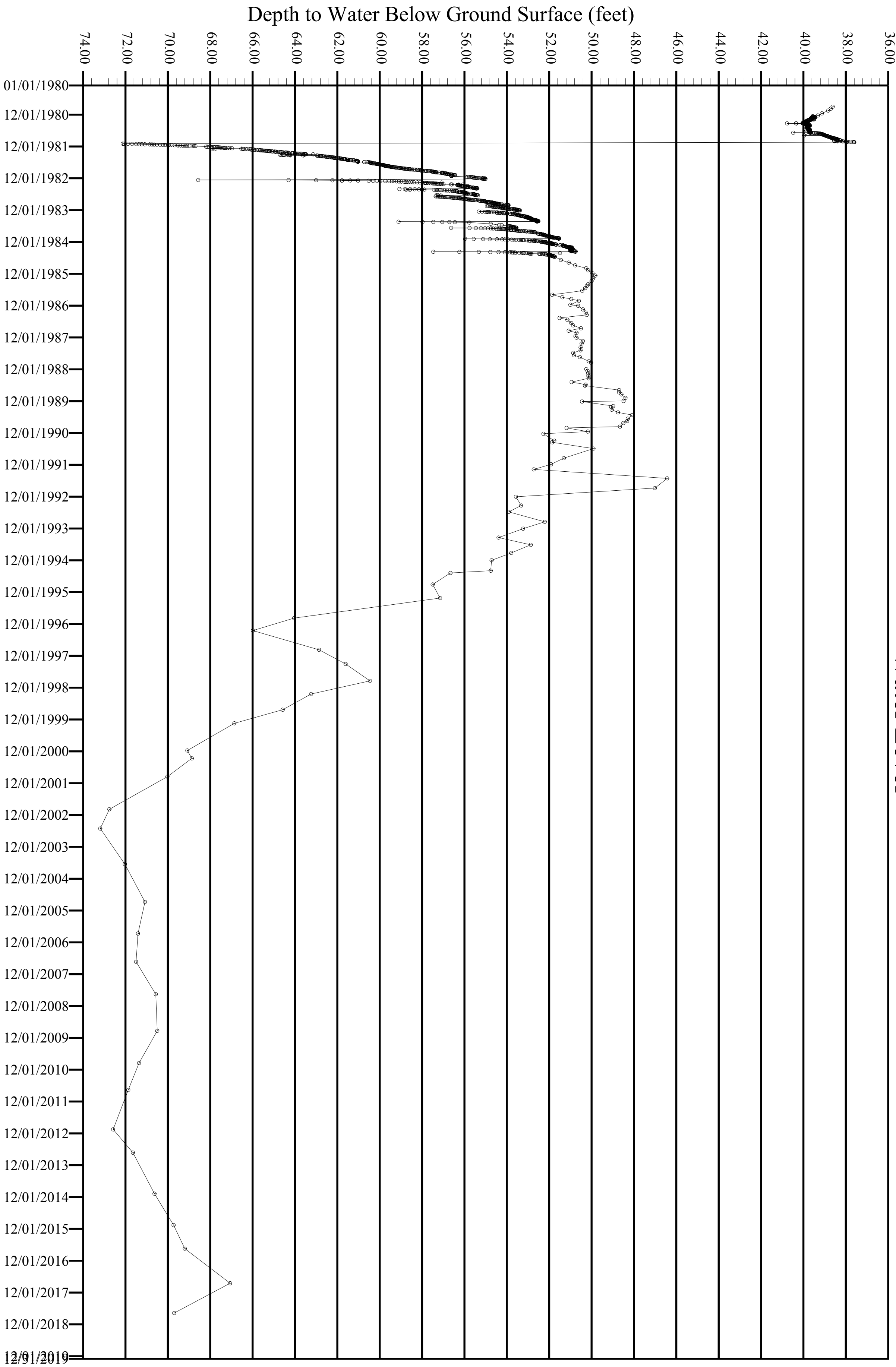
WEPO44

Water Level

WEPO49

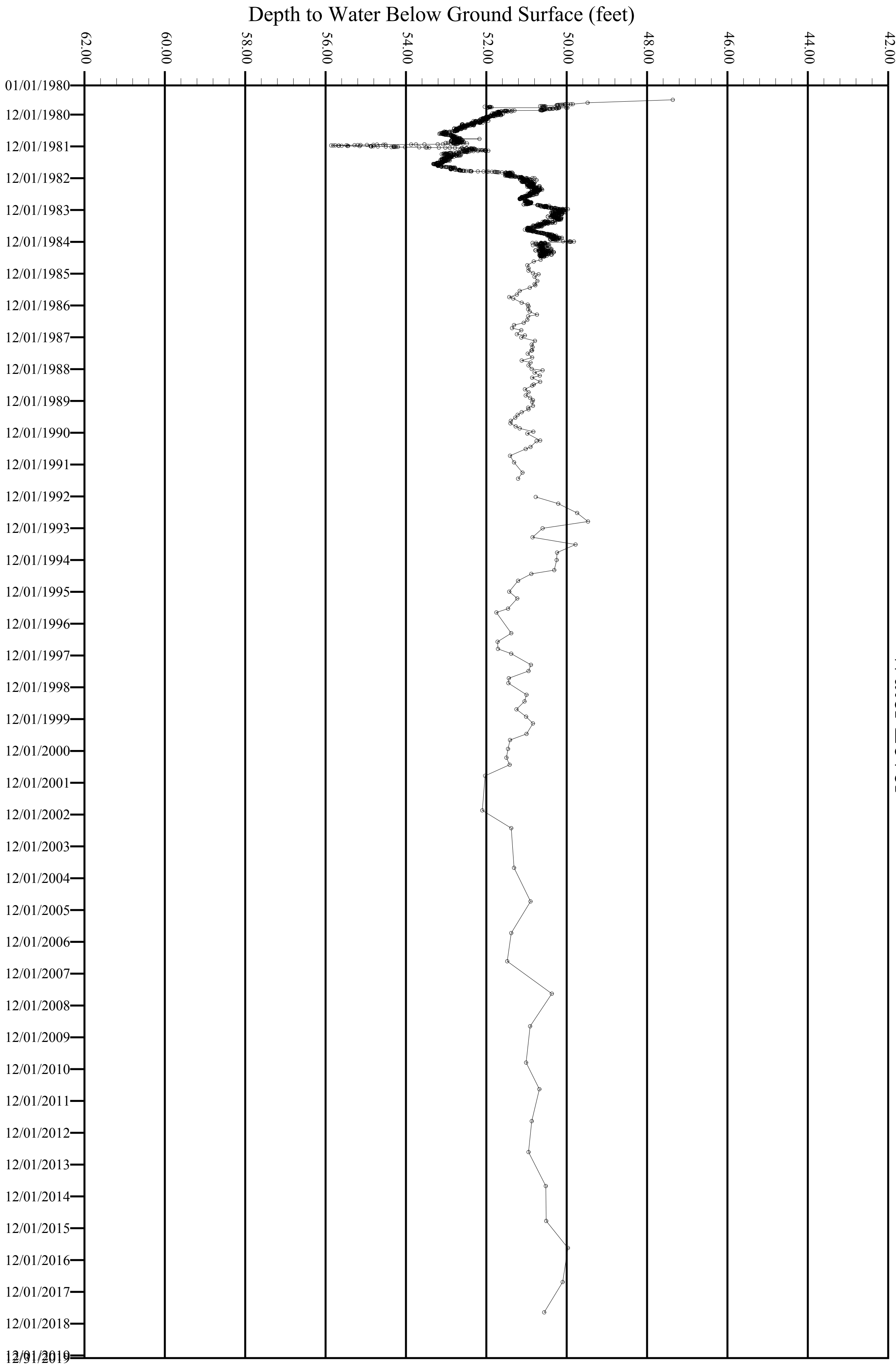


Water Level

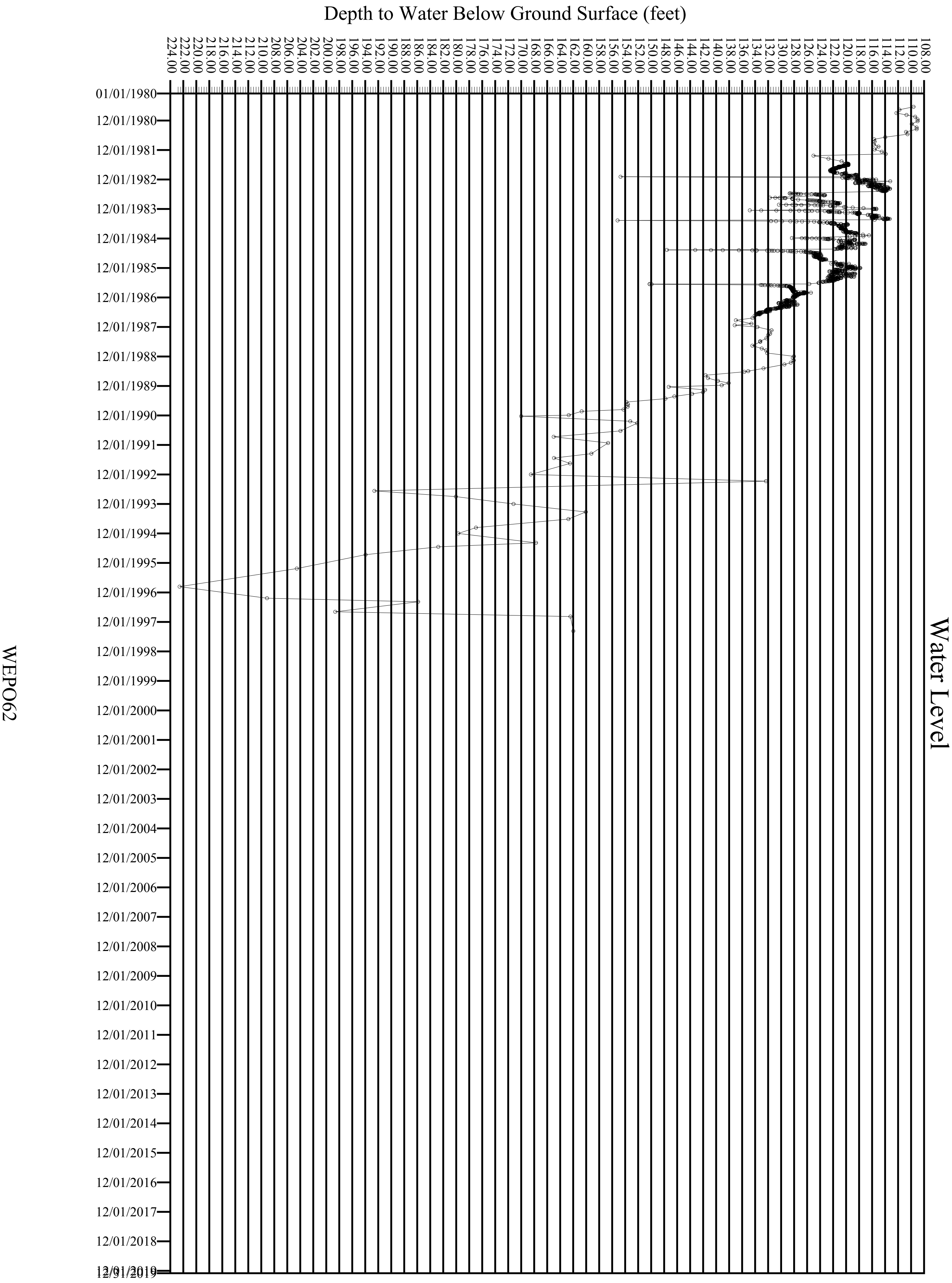


WEPO53

Water Level



WEPO54


Depth to Water Below Ground Surface (feet)
224.00
222.00
220.00
218.00
216.00
214.00
212.00
210.00
208.00
206.00
204.00
202.00
200.00
198.00
196.00
194.00
192.00
190.00
188.00
186.00
184.00
182.00
180.00
178.00
176.00
174.00
172.00
170.00
168.00
166.00
164.00
162.00
160.00
158.00
156.00
154.00
152.00
150.00
148.00
146.00
144.00
142.00
140.00
138.00
136.00
134.00
132.00
130.00
128.00
126.00
124.00
122.00
120.00
118.00
116.00
114.00
112.00
110.00
108.00
01/01/1980
12/01/1980
12/01/1981
12/01/1982
12/01/1983
12/01/1984
12/01/1985
12/01/1986
12/01/1987
12/01/1988
12/01/1989
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12/01/1992
12/01/1993
12/01/1994
12/01/1995
12/01/1996
12/01/1997
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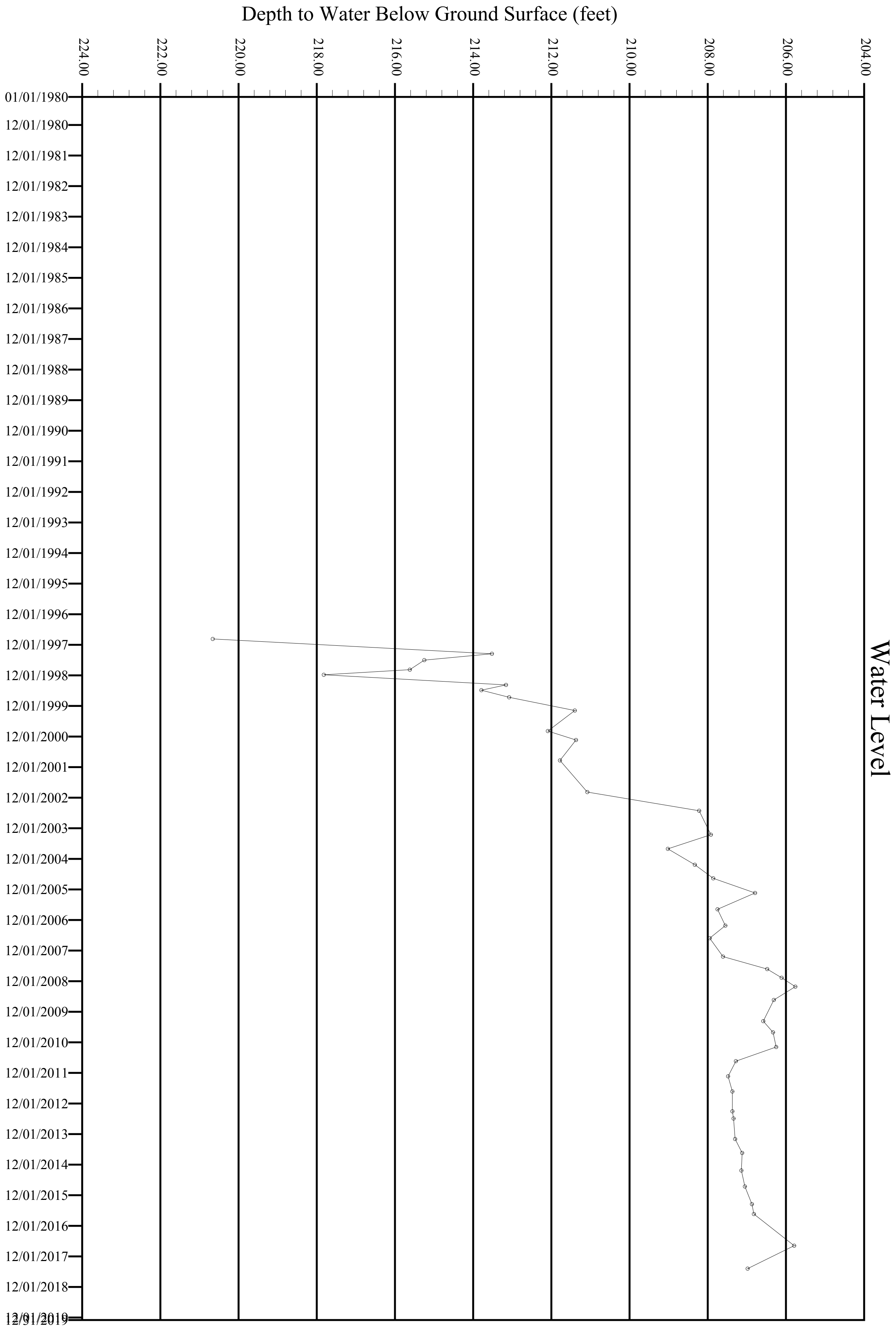
12/01/2001
12/01/2002
12/01/2003
12/01/2004
12/01/2005
12/01/2006
12/01/2007
12/01/2008
12/01/2009
12/01/2010
12/01/2011
12/01/2012
12/01/2013
12/01/2014
12/01/2015
12/01/2016
12/01/2017
12/01/2018
12/01/2019
12/31/2019
Water Level
WEPO62

WEPO62R

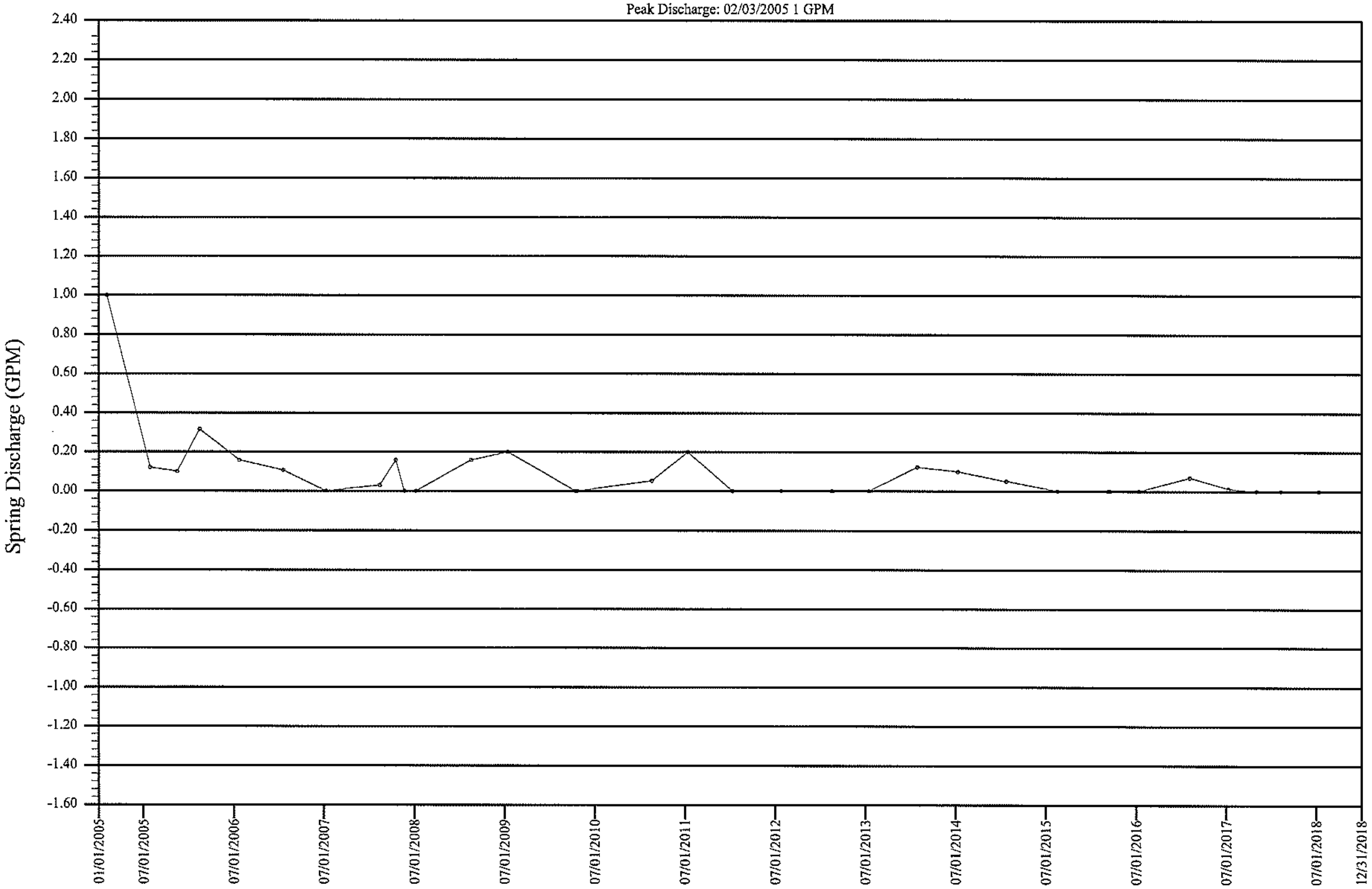

Water Level
Depth to Water Below Ground Surface (feet)
224.00
222.00
220.00
218.00
216.00
214.00
212.00
210.00
208.00
206.00
204.00
01/01/1980
12/01/1980
12/01/1981
12/01/1982
12/01/1983
12/01/1984
12/01/1985
12/01/1986
12/01/1987
12/01/1988
12/01/1989
12/01/1990
12/01/1991
12/01/1992
12/01/1993
12/01/1994
12/01/1995
12/01/1996
12/01/1997
12/01/1998
12/01/1999
12/01/2000
12/01/2001
12/01/2002
12/01/2003
12/01/2004
12/01/2005
12/01/2006
12/01/2007
12/01/2008
12/01/2009
12/01/2010
12/01/2011
12/01/2012
12/01/2013
12/01/2014
12/01/2015
12/01/2016
12/01/2017
12/01/2018
12/01/2019
12/31/2019

Attachment 3-2

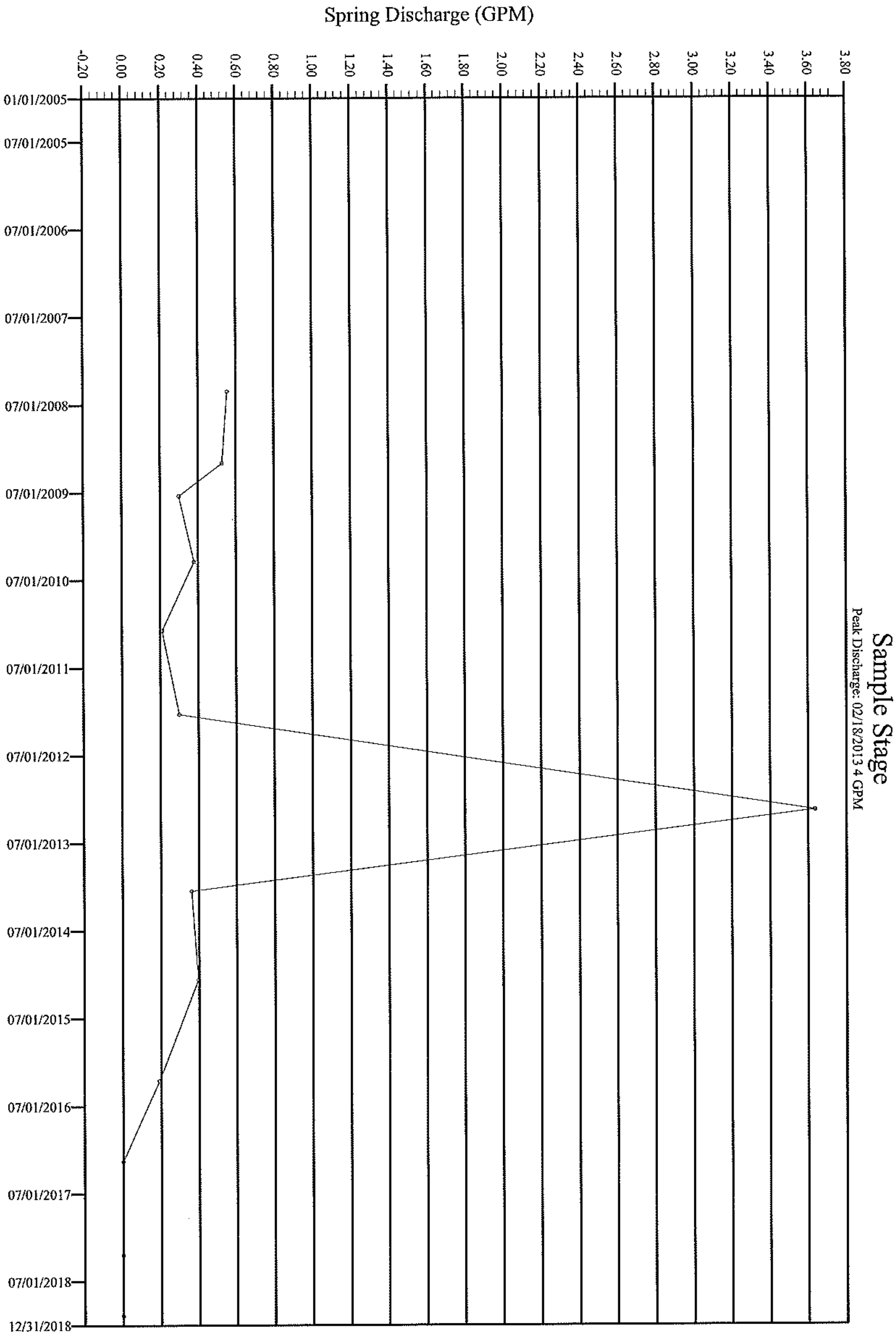
Graphs of Spring Discharge Manual Measurements

Sample Stage

Peak Discharge: 02/03/2005 1 GPM



NSPG22



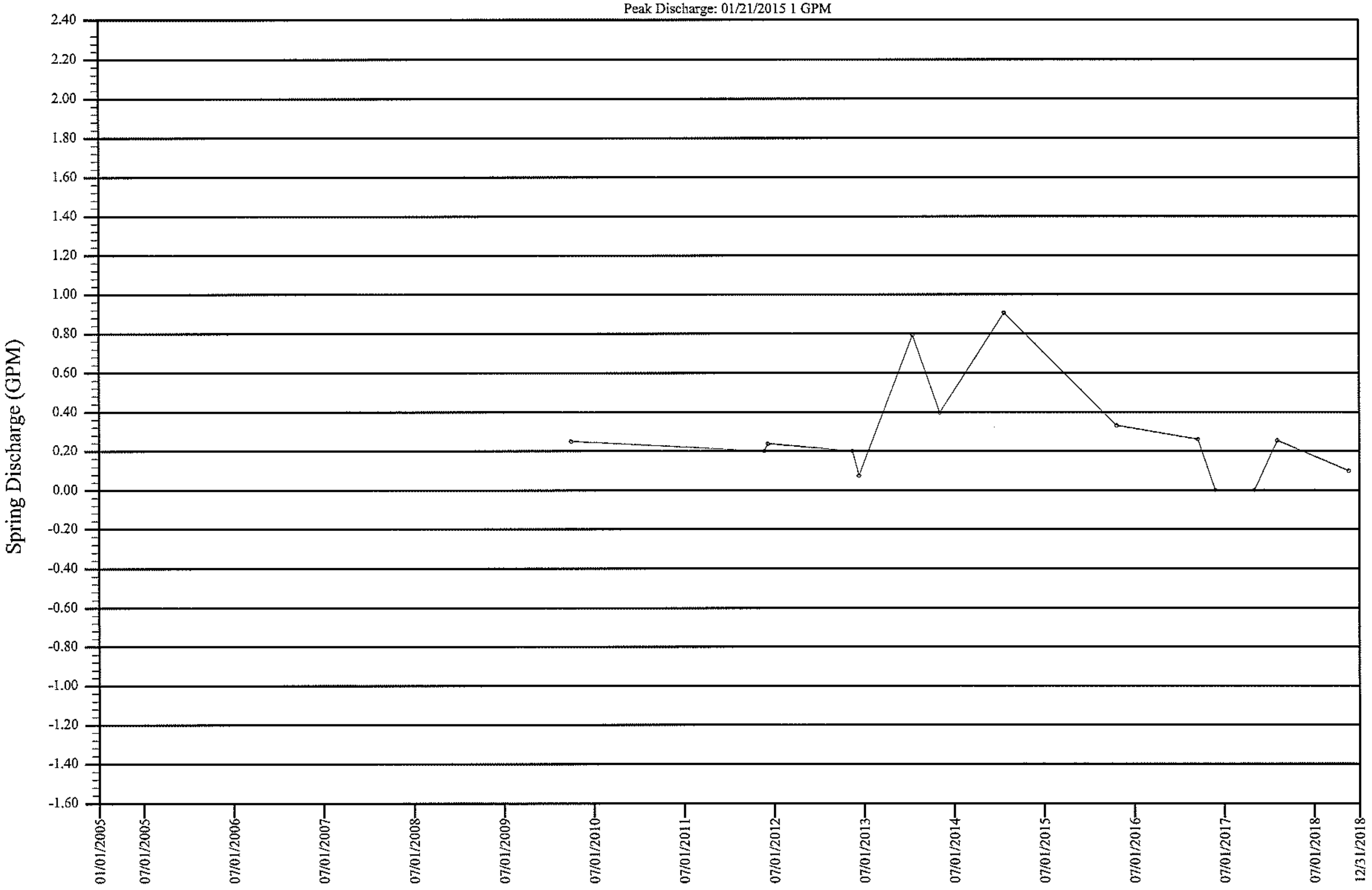
Sample Stage

Peak Discharge: 02/18/2013 4 GPM

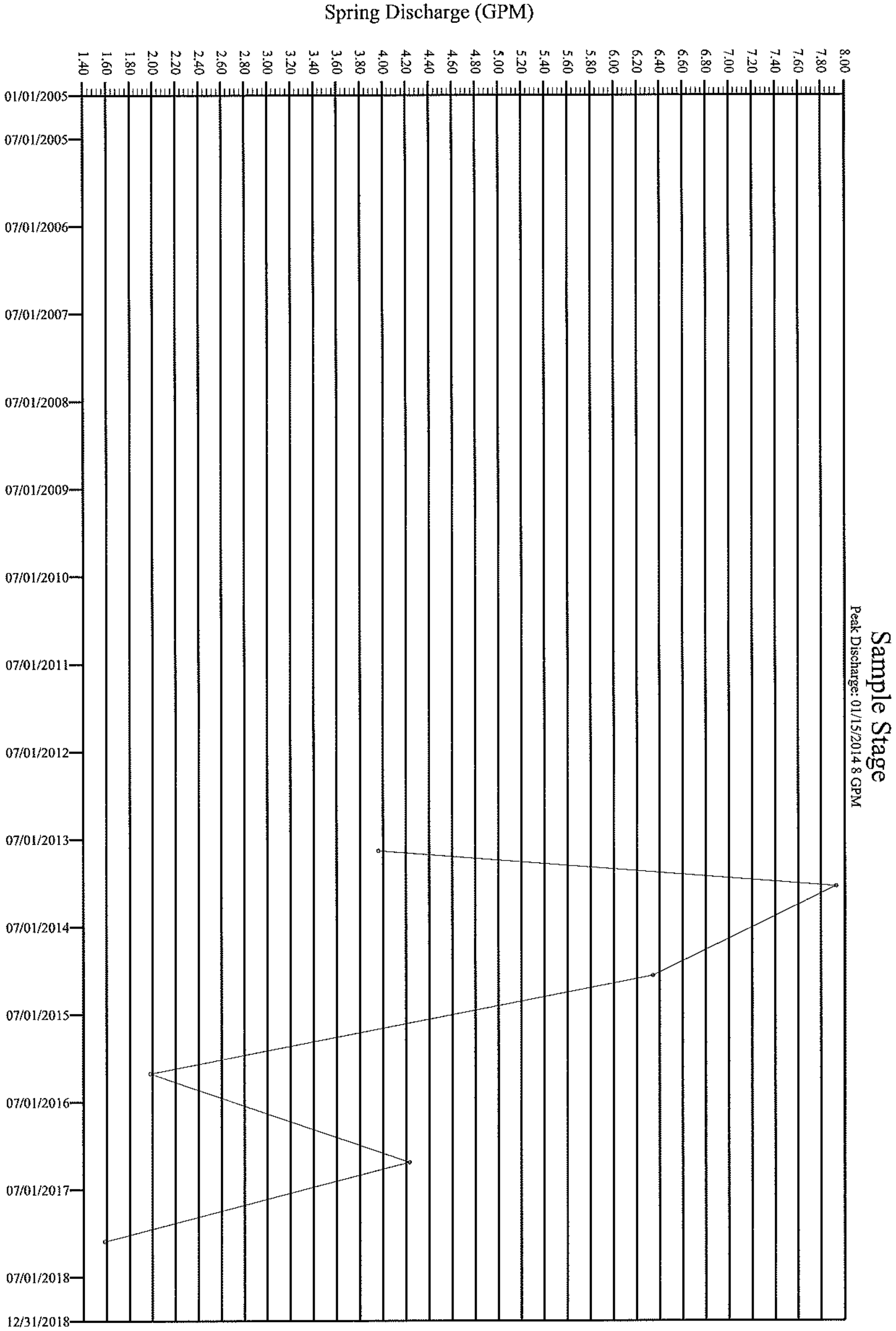
NSPG61

Sample Stage

Peak Discharge: 01/21/2015 1 GPM



NSPG62



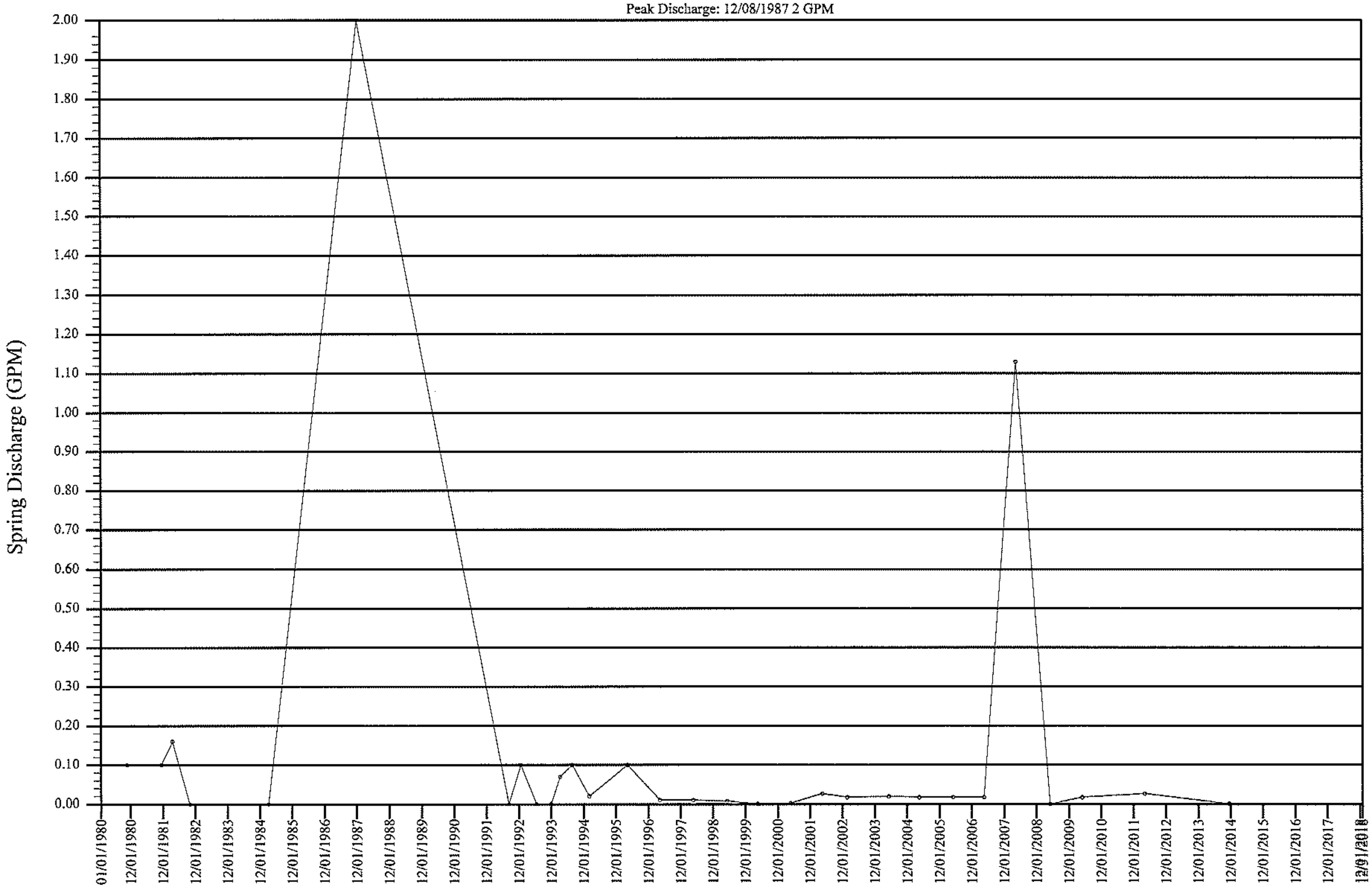
Sample Stage

Peak Discharge: 01/15/2014 8 GPM

NSPG64

Sample Stage

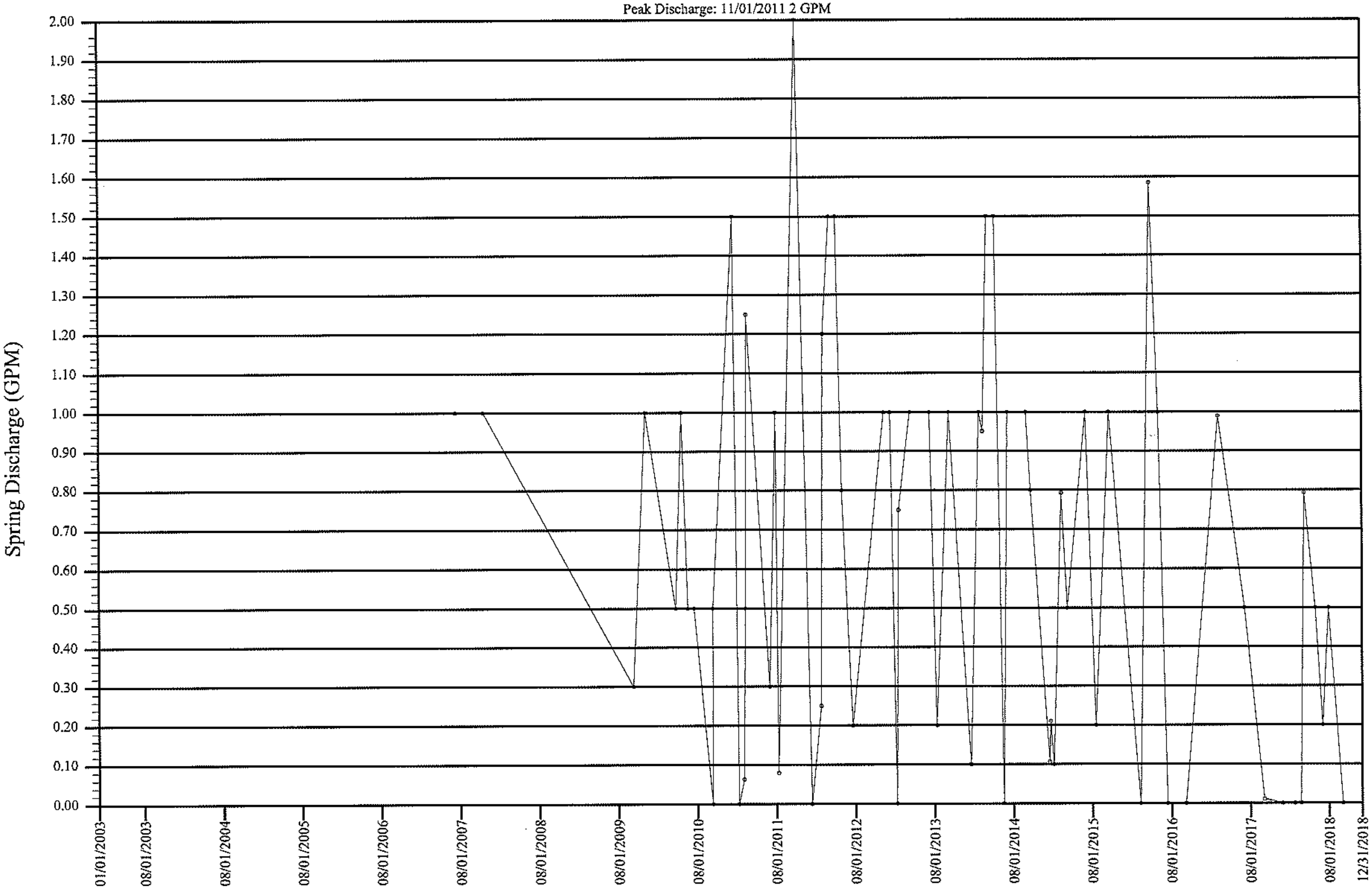
Peak Discharge: 12/08/1987 2 GPM



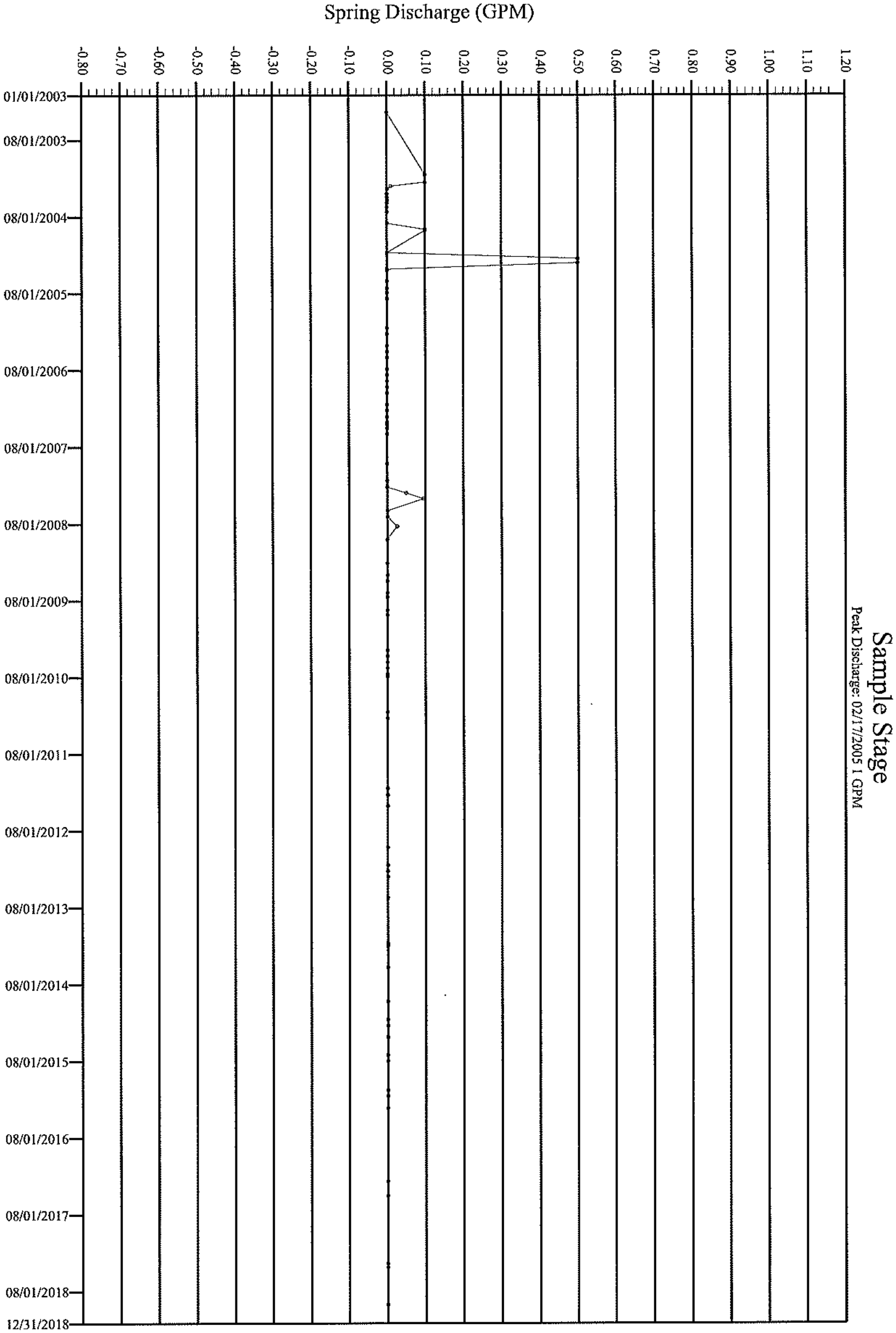
NSPG111

Sample Stage

Peak Discharge: 11/01/2011 2 GPM



NSPG151


Sample Stage
Peak Discharge: 02/17/2005 1 GPM
Spring Discharge (GPM)
-0.80
-0.70
-0.60
-0.50
-0.40
-0.30
-0.20
-0.10
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
1.10
1.20
01/01/2003
08/01/2003
08/01/2004
08/01/2005
08/01/2006
08/01/2007
08/01/2008
08/01/2009
08/01/2010
08/01/2011
08/01/2012
08/01/2013
08/01/2014
08/01/2015
08/01/2016
08/01/2017
08/01/2018
12/31/2018

NSPG162

Attachment 3-3

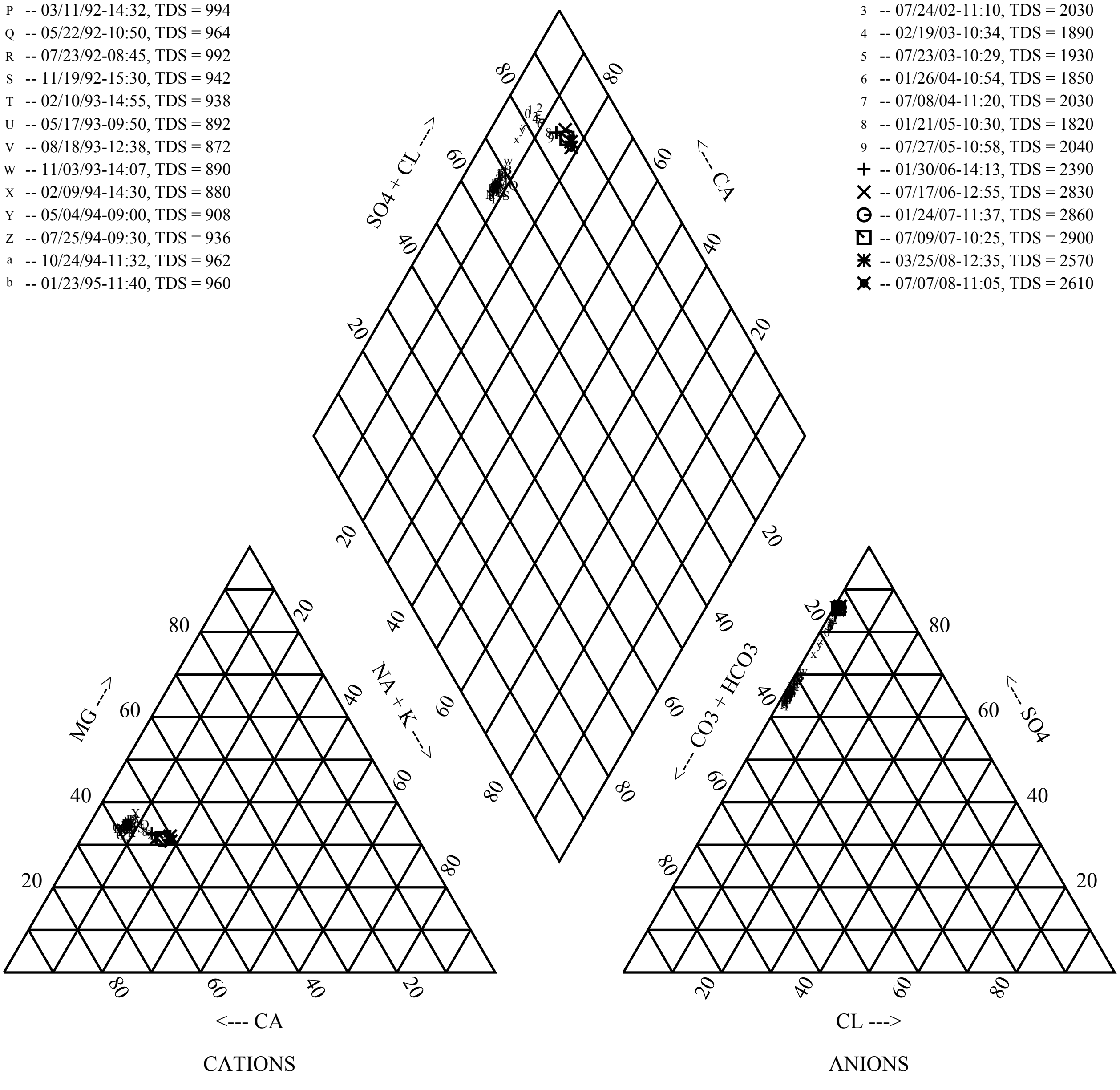
Trilinear Diagrams for Alluvial and Wepo Wells
Proximate to the J-1/N-6, J-16 and N-14 TOJ Parcels

ALUV17

A -- 07/17/86-12:40, TDS = 986
B -- 10/15/86-11:58, TDS = 916
C -- 06/07/87-10:58, TDS = 988
D -- 10/26/87-14:25, TDS = 974
E -- 05/02/88-10:20, TDS = 948
F -- 11/28/88-12:50, TDS = 976
G -- 05/31/89-13:45, TDS = 914
H -- 09/12/89-10:27, TDS = 990
I -- 05/10/90-08:40, TDS = 1012
J -- 09/07/90-17:32, TDS = 1000
K -- 11/15/90-12:34, TDS = 1034
L -- 02/07/91-12:30, TDS = 1006
M -- 05/28/91-13:20, TDS = 966
N -- 09/26/91-09:55, TDS = 972
O -- 11/26/91-10:26, TDS = 976
P -- 03/11/92-14:32, TDS = 994
Q -- 05/22/92-10:50, TDS = 964
R -- 07/23/92-08:45, TDS = 992
S -- 11/19/92-15:30, TDS = 942
T -- 02/10/93-14:55, TDS = 938
U -- 05/17/93-09:50, TDS = 892
V -- 08/18/93-12:38, TDS = 872
W -- 11/03/93-14:07, TDS = 890
X -- 02/09/94-14:30, TDS = 880
Y -- 05/04/94-09:00, TDS = 908
Z -- 07/25/94-09:30, TDS = 936
a -- 10/24/94-11:32, TDS = 962
b -- 01/23/95-11:40, TDS = 960

c -- 04/19/95-11:00, TDS = 970
d -- 07/14/95-11:40, TDS = 990
e -- 10/27/95-12:15, TDS = 940
f -- 01/29/96-14:40, TDS = 940
g -- 04/10/96-09:50, TDS = 1010
h -- 07/15/96-09:15, TDS = 1030
i -- 10/30/96-11:20, TDS = 1010
j -- 02/04/97-10:46, TDS = 990
k -- 04/14/97-13:00, TDS = 1010
l -- 07/07/97-09:18, TDS = 1020
m -- 10/08/97-11:11, TDS = 1040
n -- 01/16/98-12:33, TDS = 920

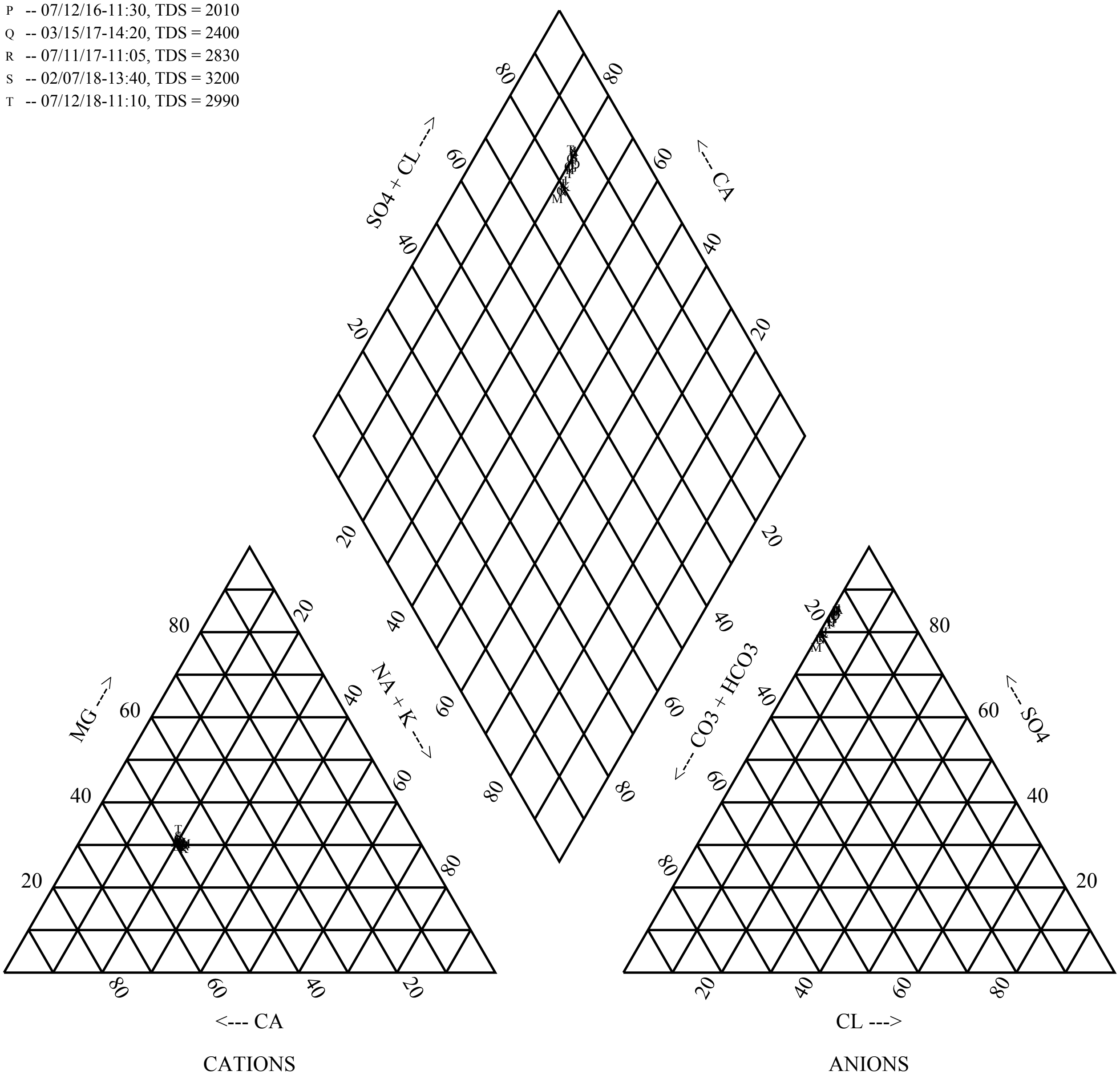
o -- 04/20/98-11:40, TDS = 950
p -- 07/13/98-12:34, TDS = 990
q -- 10/09/98-08:40, TDS = 950
r -- 01/18/99-14:30, TDS = 920
s -- 04/19/99-11:25, TDS = 950
t -- 07/05/99-11:50, TDS = 1100
u -- 10/05/99-11:33, TDS = 1000
v -- 01/06/00-12:00, TDS = 1050
w -- 04/07/00-12:12, TDS = 1140
x -- 07/21/00-13:34, TDS = 1370
y -- 10/04/00-08:55, TDS = 1500
z -- 01/08/01-11:00, TDS = 1510
0 -- 04/09/01-10:35, TDS = 1630
1 -- 07/06/01-12:05, TDS = 1950
2 -- 04/22/02-09:30, TDS = 1770
3 -- 07/24/02-11:10, TDS = 2030
4 -- 02/19/03-10:34, TDS = 1890
5 -- 07/23/03-10:29, TDS = 1930
6 -- 01/26/04-10:54, TDS = 1850
7 -- 07/08/04-11:20, TDS = 2030
8 -- 01/21/05-10:30, TDS = 1820
9 -- 07/27/05-10:58, TDS = 2040
+ -- 01/30/06-14:13, TDS = 2390
× -- 07/17/06-12:55, TDS = 2830
⊖ -- 01/24/07-11:37, TDS = 2860
⧄ -- 07/09/07-10:25, TDS = 2900
✳ -- 03/25/08-12:35, TDS = 2570
✖ -- 07/07/08-11:05, TDS = 2610



Percent Of Total Milliequivalents Per Liter

ALUV17 (Continued)

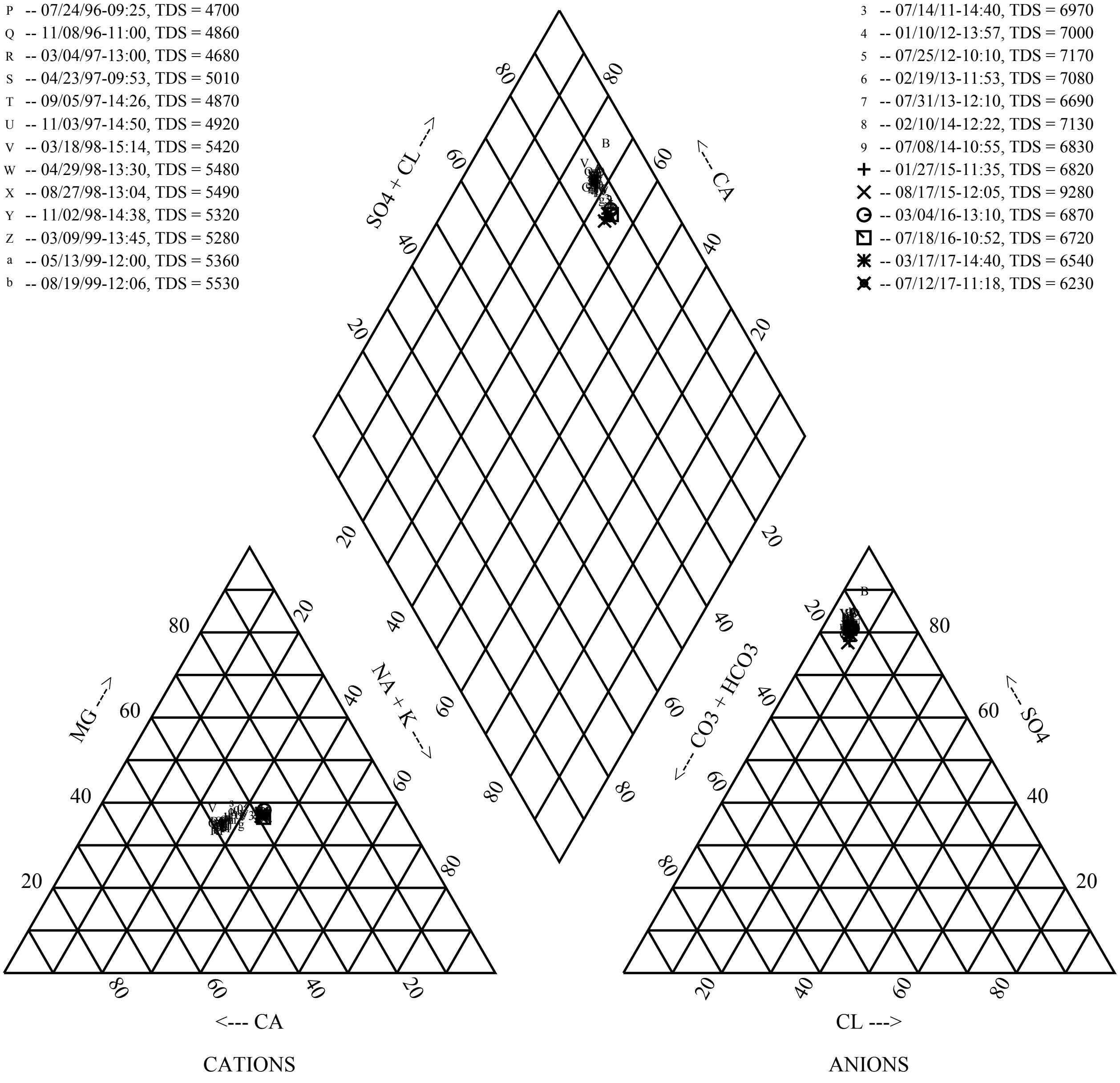
A -- 02/27/09-16:10, TDS = 2590
B -- 07/10/09-14:35, TDS = 2680
C -- 03/23/10-11:08, TDS = 2470
D -- 07/22/10-11:30, TDS = 2690
E -- 02/28/11-13:15, TDS = 2470
F -- 07/13/11-11:40, TDS = 2520
G -- 01/09/12-11:53, TDS = 2430
H -- 07/16/12-11:25, TDS = 2320
I -- 02/07/13-13:51, TDS = 2270
J -- 07/15/13-10:15, TDS = 2160
K -- 01/22/14-14:00, TDS = 2160
L -- 07/07/14-11:50, TDS = 1990
M -- 01/26/15-14:35, TDS = 1980
N -- 07/27/15-12:18, TDS = 1980
O -- 03/16/16-14:45, TDS = 1920
P -- 07/12/16-11:30, TDS = 2010
Q -- 03/15/17-14:20, TDS = 2400
R -- 07/11/17-11:05, TDS = 2830
S -- 02/07/18-13:40, TDS = 3200
T -- 07/12/18-11:10, TDS = 2990



Percent Of Total Milliequivalents Per Liter

ALUV193

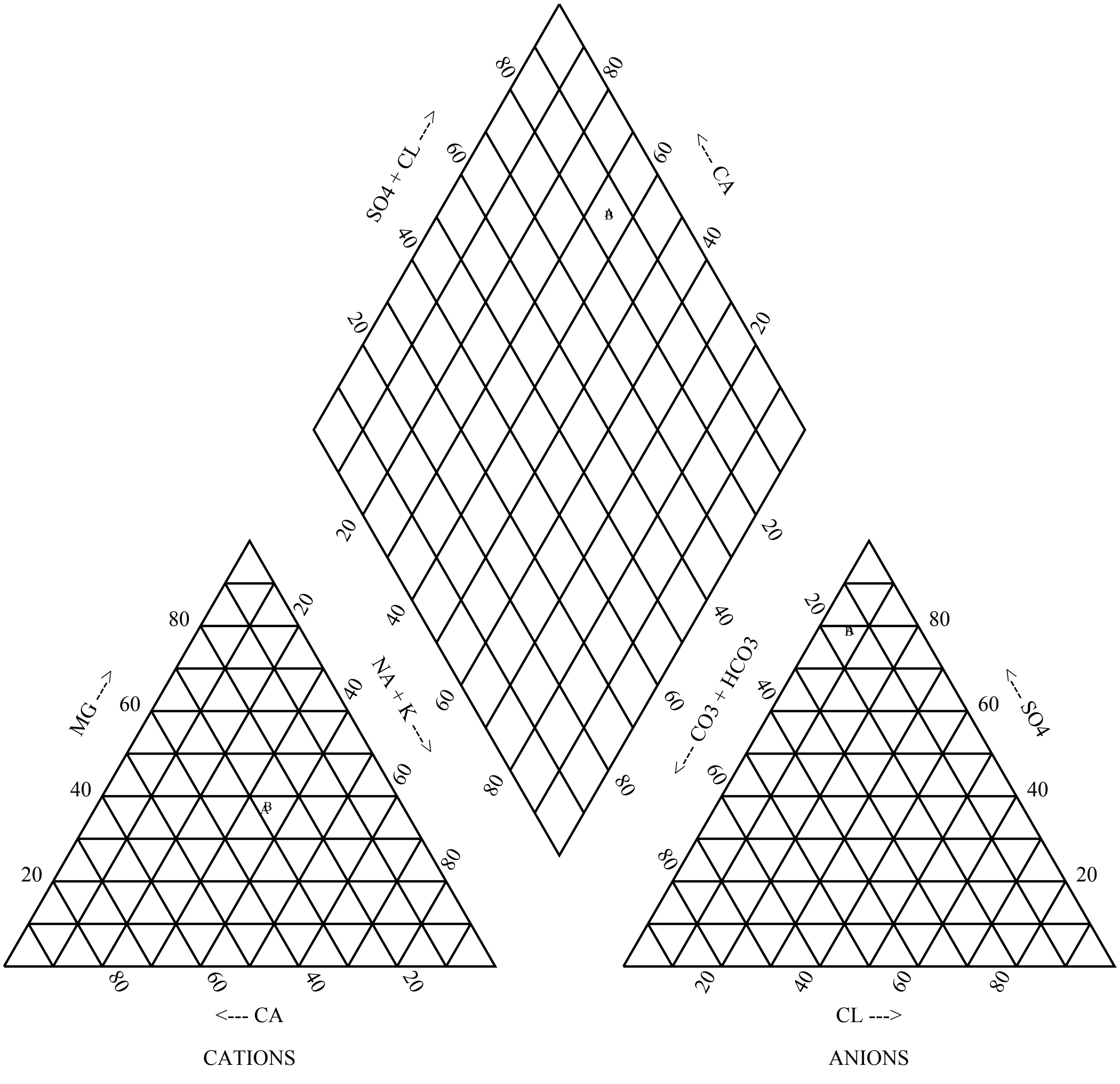
A -- 10/31/92-12:35, TDS = 4724
B -- 02/11/93-14:56, TDS = 4678
C -- 05/24/93-11:15, TDS = 4864
D -- 09/21/93-12:45, TDS = 4866
E -- 11/22/93-13:48, TDS = 4858
F -- 03/23/94-14:37, TDS = 4794
G -- 05/03/94-10:42, TDS = 4088
H -- 07/29/94-08:55, TDS = 4776
I -- 10/27/94-13:17, TDS = 4584
J -- 02/22/95-13:47, TDS = 4640
K -- 04/25/95-11:50, TDS = 4630
L -- 07/25/95-09:57, TDS = 4440
M -- 11/08/95-14:58, TDS = 4590
N -- 02/07/96-13:03, TDS = 4700
O -- 04/23/96-12:35, TDS = 4830
P -- 07/24/96-09:25, TDS = 4700
Q -- 11/08/96-11:00, TDS = 4860
R -- 03/04/97-13:00, TDS = 4680
S -- 04/23/97-09:53, TDS = 5010
T -- 09/05/97-14:26, TDS = 4870
U -- 11/03/97-14:50, TDS = 4920
V -- 03/18/98-15:14, TDS = 5420
W -- 04/29/98-13:30, TDS = 5480
X -- 08/27/98-13:04, TDS = 5490
Y -- 11/02/98-14:38, TDS = 5320
Z -- 03/09/99-13:45, TDS = 5280
a -- 05/13/99-12:00, TDS = 5360
b -- 08/19/99-12:06, TDS = 5530
c -- 10/20/99-09:07, TDS = 5230
d -- 02/09/00-13:29, TDS = 5270
e -- 05/18/00-12:40, TDS = 5400
f -- 07/27/00-13:37, TDS = 5280
g -- 10/20/00-12:25, TDS = 5200
h -- 02/15/01-13:57, TDS = 5240
i -- 05/08/01-09:41, TDS = 5240
j -- 07/25/01-10:50, TDS = 5190
k -- 02/13/02-08:55, TDS = 5050
l -- 07/31/02-09:10, TDS = 5280
m -- 02/17/03-11:29, TDS = 5110
n -- 07/21/03-11:20, TDS = 5350
o -- 01/29/04-13:08, TDS = 5440
p -- 07/22/04-09:40, TDS = 5690
q -- 02/03/05-12:42, TDS = 5500
r -- 07/28/05-09:00, TDS = 5850
s -- 01/17/06-14:50, TDS = 6010
t -- 08/03/06-12:20, TDS = 6190
u -- 02/06/07-12:50, TDS = 6040
v -- 07/19/07-09:13, TDS = 6400
w -- 03/03/08-14:40, TDS = 6290
x -- 07/09/08-09:48, TDS = 6270
y -- 03/18/09-13:35, TDS = 6680
z -- 07/23/09-11:25, TDS = 6760
0 -- 03/22/10-12:40, TDS = 6780
1 -- 08/09/10-15:45, TDS = 6690
2 -- 02/15/11-14:58, TDS = 6910
3 -- 07/14/11-14:40, TDS = 6970
4 -- 01/10/12-13:57, TDS = 7000
5 -- 07/25/12-10:10, TDS = 7170
6 -- 02/19/13-11:53, TDS = 7080
7 -- 07/31/13-12:10, TDS = 6690
8 -- 02/10/14-12:22, TDS = 7130
9 -- 07/08/14-10:55, TDS = 6830
+ -- 01/27/15-11:35, TDS = 6820
✕ -- 08/17/15-12:05, TDS = 9280
⊖ -- 03/04/16-13:10, TDS = 6870
⊠ -- 07/18/16-10:52, TDS = 6720
✳ -- 03/17/17-14:40, TDS = 6540
✖ -- 07/12/17-11:18, TDS = 6230



Percent Of Total Milliequivalents Per Liter

ALUV193 (Continued)

A -- 02/26/18-14:50, TDS = 6390
B -- 07/11/18-12:35, TDS = 6230



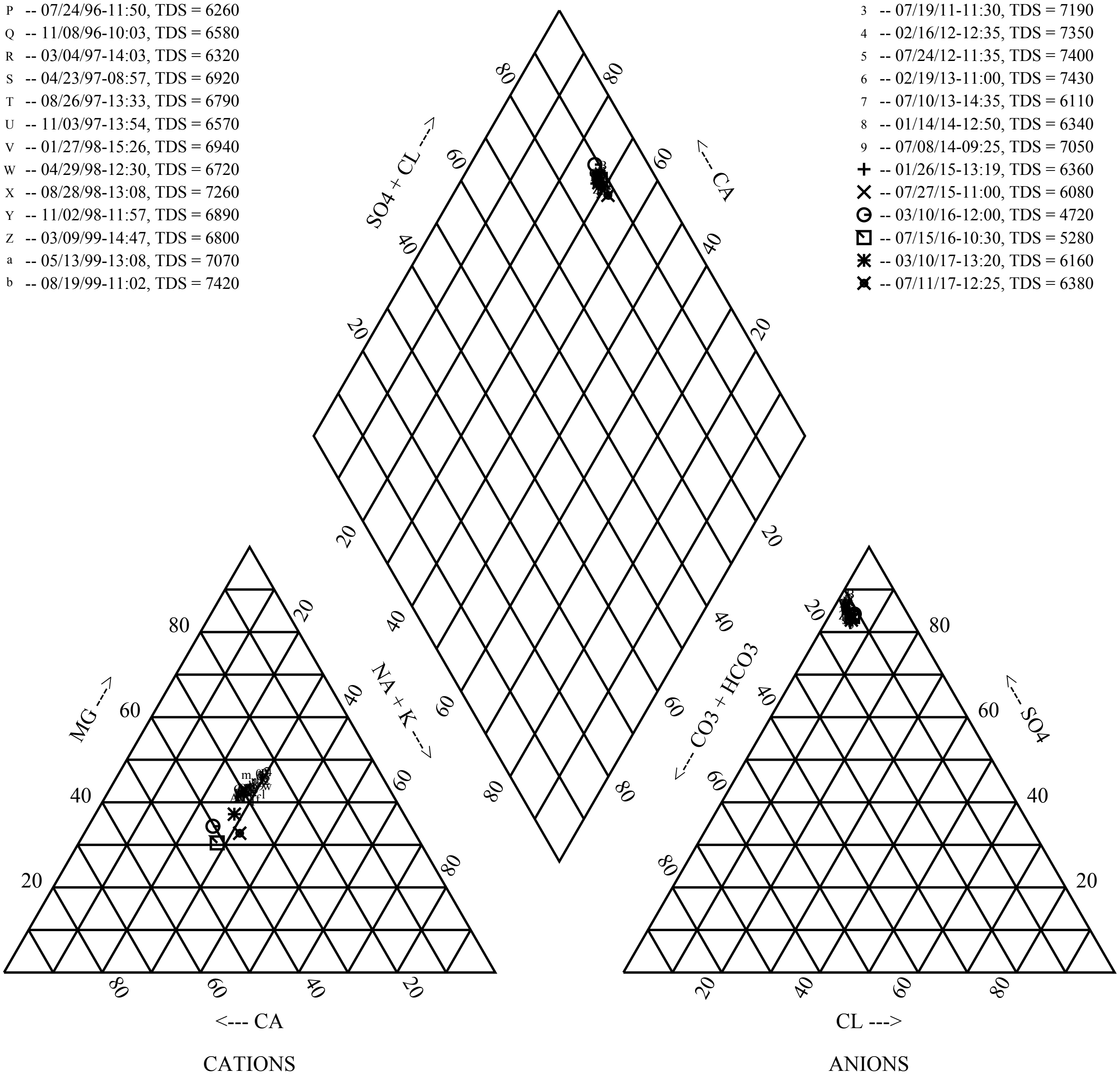
Percent Of Total Milliequivalents Per Liter

ALUV197

A -- 10/30/92-12:20, TDS = 5754
B -- 01/29/93-14:05, TDS = 5842
C -- 05/08/93-11:50, TDS = 6076
D -- 09/21/93-08:36, TDS = 5643
E -- 11/22/93-10:00, TDS = 5962
F -- 03/23/94-13:29, TDS = 5862
G -- 04/21/94-09:50, TDS = 5602
H -- 07/29/94-08:03, TDS = 6118
I -- 10/27/94-09:45, TDS = 5946
J -- 02/22/95-14:55, TDS = 6300
K -- 05/02/95-08:00, TDS = 6170
L -- 07/17/95-08:33, TDS = 6450
M -- 11/08/95-14:02, TDS = 6400
N -- 02/07/96-11:57, TDS = 6580
O -- 04/23/96-13:35, TDS = 6460
P -- 07/24/96-11:50, TDS = 6260
Q -- 11/08/96-10:03, TDS = 6580
R -- 03/04/97-14:03, TDS = 6320
S -- 04/23/97-08:57, TDS = 6920
T -- 08/26/97-13:33, TDS = 6790
U -- 11/03/97-13:54, TDS = 6570
V -- 01/27/98-15:26, TDS = 6940
W -- 04/29/98-12:30, TDS = 6720
X -- 08/28/98-13:08, TDS = 7260
Y -- 11/02/98-11:57, TDS = 6890
Z -- 03/09/99-14:47, TDS = 6800
a -- 05/13/99-13:08, TDS = 7070
b -- 08/19/99-11:02, TDS = 7420

c -- 10/15/99-10:05, TDS = 6980
d -- 02/09/00-12:36, TDS = 6890
e -- 05/18/00-11:38, TDS = 7300
f -- 07/26/00-13:59, TDS = 7090
g -- 10/20/00-13:28, TDS = 7040
h -- 02/15/01-12:43, TDS = 7240
i -- 05/07/01-11:45, TDS = 7410
j -- 07/24/01-09:57, TDS = 7340
k -- 02/14/02-10:20, TDS = 7340
l -- 07/26/02-09:10, TDS = 7730
m -- 02/20/03-11:11, TDS = 7330
n -- 08/07/03-09:55, TDS = 7540

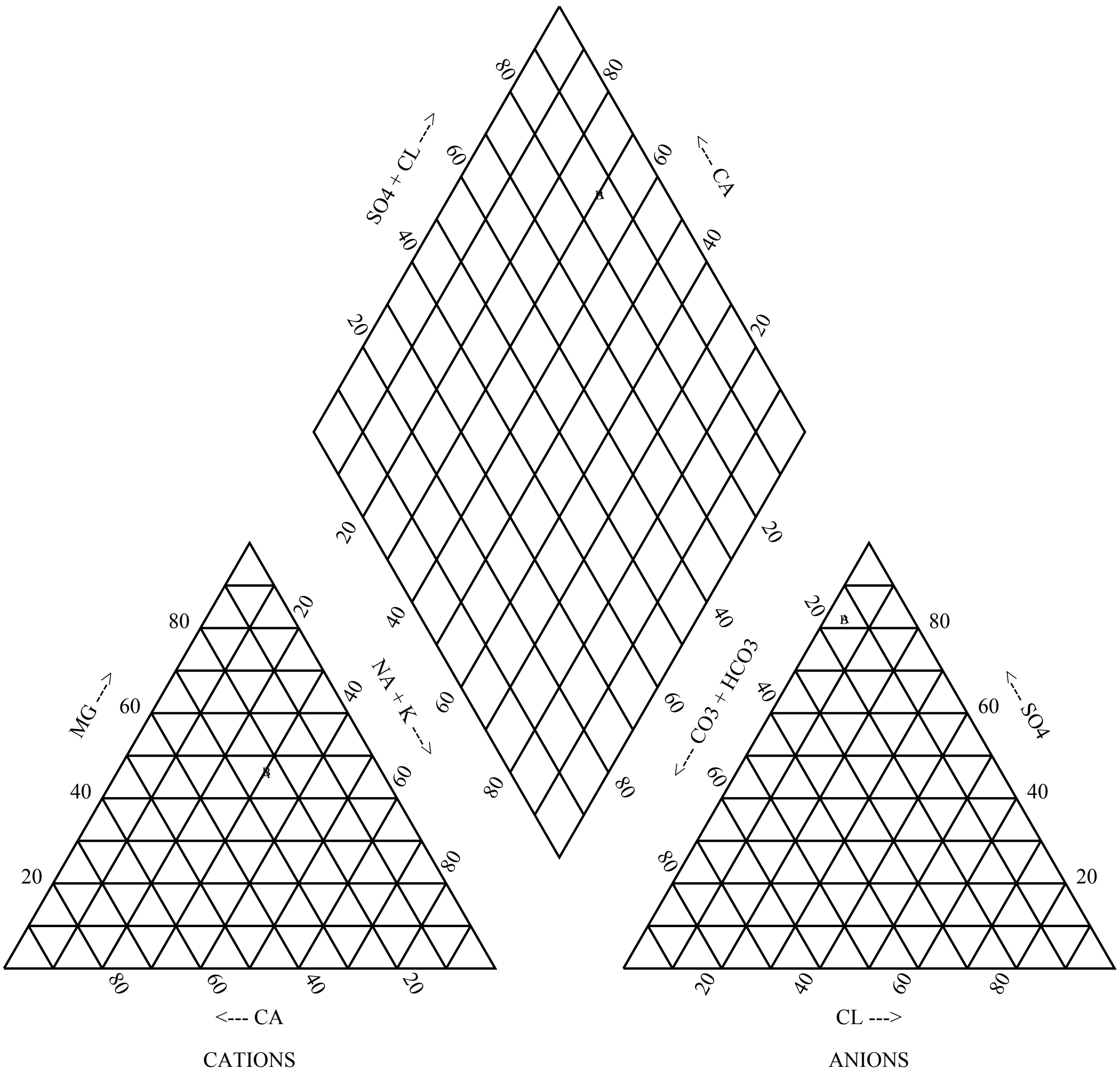
o -- 01/29/04-12:07, TDS = 7300
p -- 07/22/04-08:38, TDS = 7490
q -- 03/09/05-12:00, TDS = 7440
r -- 08/16/05-14:00, TDS = 7040
s -- 01/17/06-13:11, TDS = 7350
t -- 08/16/06-11:14, TDS = 7400
u -- 03/08/07-12:07, TDS = 7260
v -- 07/10/07-11:02, TDS = 7520
w -- 03/10/08-14:09, TDS = 7430
x -- 07/14/08-10:59, TDS = 7250
y -- 02/25/09-12:52, TDS = 7180
z -- 07/22/09-09:36, TDS = 7180
0 -- 03/22/10-10:40, TDS = 6950
1 -- 09/14/10-10:43, TDS = 7060
2 -- 02/15/11-13:11, TDS = 7110
3 -- 07/19/11-11:30, TDS = 7190
4 -- 02/16/12-12:35, TDS = 7350
5 -- 07/24/12-11:35, TDS = 7400
6 -- 02/19/13-11:00, TDS = 7430
7 -- 07/10/13-14:35, TDS = 6110
8 -- 01/14/14-12:50, TDS = 6340
9 -- 07/08/14-09:25, TDS = 7050
+ -- 01/26/15-13:19, TDS = 6360
× -- 07/27/15-11:00, TDS = 6080
⊖ -- 03/10/16-12:00, TDS = 4720
⧄ -- 07/15/16-10:30, TDS = 5280
✳ -- 03/10/17-13:20, TDS = 6160
✱ -- 07/11/17-12:25, TDS = 6380



Percent Of Total Milliequivalents Per Liter

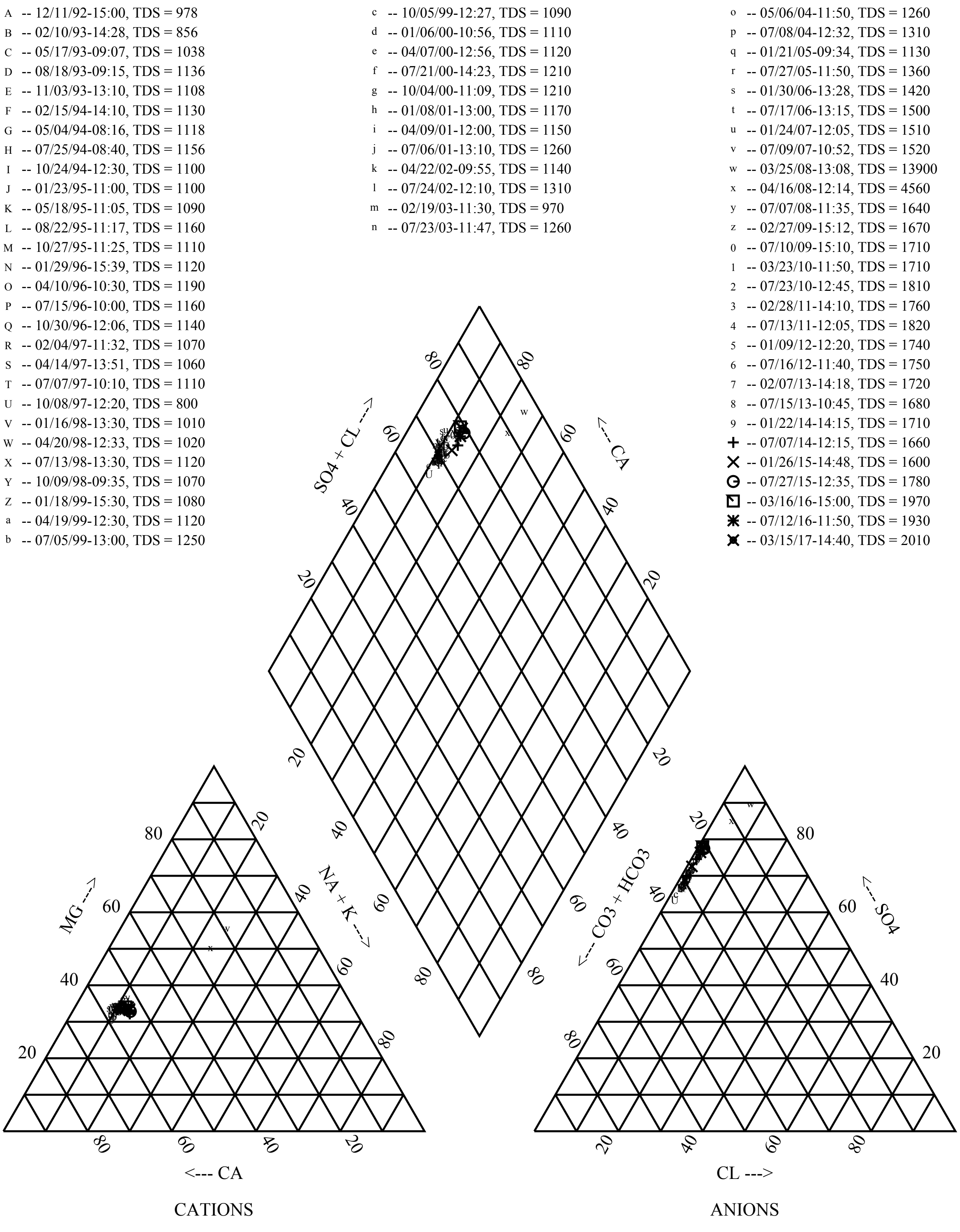
ALUV197 (Continued)

A -- 02/02/18-12:20, TDS = 6570
B -- 07/10/18-11:00, TDS = 6470



Percent Of Total Milliequivalents Per Liter

ALUV200

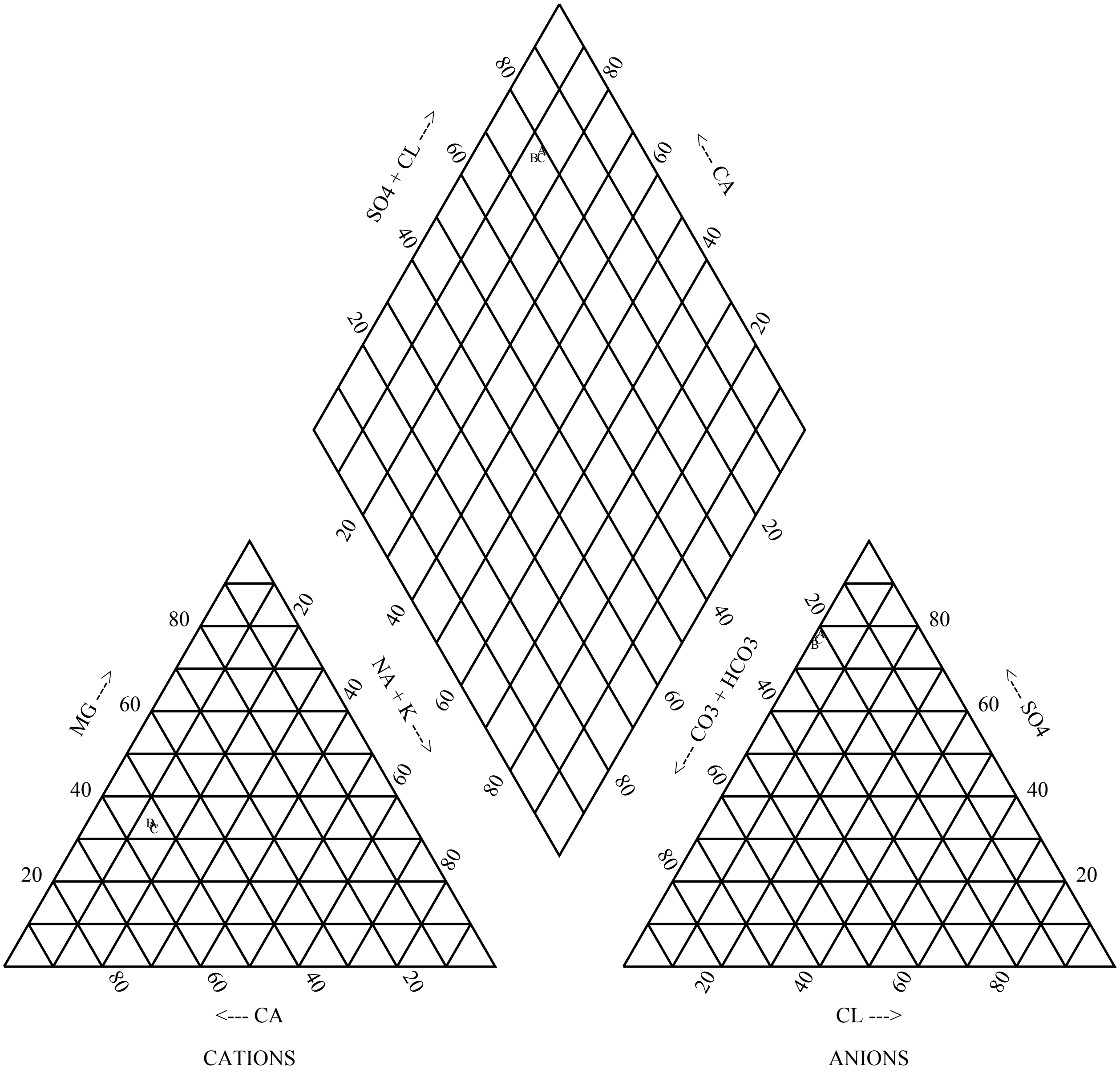


A -- 12/11/92-15:00, TDS = 978
B -- 02/10/93-14:28, TDS = 856
C -- 05/17/93-09:07, TDS = 1038
D -- 08/18/93-09:15, TDS = 1136
E -- 11/03/93-13:10, TDS = 1108
F -- 02/15/94-14:10, TDS = 1130
G -- 05/04/94-08:16, TDS = 1118
H -- 07/25/94-08:40, TDS = 1156
I -- 10/24/94-12:30, TDS = 1100
J -- 01/23/95-11:00, TDS = 1100
K -- 05/18/95-11:05, TDS = 1090
L -- 08/22/95-11:17, TDS = 1160
M -- 10/27/95-11:25, TDS = 1110
N -- 01/29/96-15:39, TDS = 1120
O -- 04/10/96-10:30, TDS = 1190
P -- 07/15/96-10:00, TDS = 1160
Q -- 10/30/96-12:06, TDS = 1140
R -- 02/04/97-11:32, TDS = 1070
S -- 04/14/97-13:51, TDS = 1060
T -- 07/07/97-10:10, TDS = 1110
U -- 10/08/97-12:20, TDS = 800
V -- 01/16/98-13:30, TDS = 1010
W -- 04/20/98-12:33, TDS = 1020
X -- 07/13/98-13:30, TDS = 1120
Y -- 10/09/98-09:35, TDS = 1070
Z -- 01/18/99-15:30, TDS = 1080
a -- 04/19/99-12:30, TDS = 1120
b -- 07/05/99-13:00, TDS = 1250
c -- 10/05/99-12:27, TDS = 1090
d -- 01/06/00-10:56, TDS = 1110
e -- 04/07/00-12:56, TDS = 1120
f -- 07/21/00-14:23, TDS = 1210
g -- 10/04/00-11:09, TDS = 1210
h -- 01/08/01-13:00, TDS = 1170
i -- 04/09/01-12:00, TDS = 1150
j -- 07/06/01-13:10, TDS = 1260
k -- 04/22/02-09:55, TDS = 1140
l -- 07/24/02-12:10, TDS = 1310
m -- 02/19/03-11:30, TDS = 970
n -- 07/23/03-11:47, TDS = 1260
o -- 05/06/04-11:50, TDS = 1260
p -- 07/08/04-12:32, TDS = 1310
q -- 01/21/05-09:34, TDS = 1130
r -- 07/27/05-11:50, TDS = 1360
s -- 01/30/06-13:28, TDS = 1420
t -- 07/17/06-13:15, TDS = 1500
u -- 01/24/07-12:05, TDS = 1510
v -- 07/09/07-10:52, TDS = 1520
w -- 03/25/08-13:08, TDS = 13900
x -- 04/16/08-12:14, TDS = 4560
y -- 07/07/08-11:35, TDS = 1640
z -- 02/27/09-15:12, TDS = 1670
0 -- 07/10/09-15:10, TDS = 1710
1 -- 03/23/10-11:50, TDS = 1710
2 -- 07/23/10-12:45, TDS = 1810
3 -- 02/28/11-14:10, TDS = 1760
4 -- 07/13/11-12:05, TDS = 1820
5 -- 01/09/12-12:20, TDS = 1740
6 -- 07/16/12-11:40, TDS = 1750
7 -- 02/07/13-14:18, TDS = 1720
8 -- 07/15/13-10:45, TDS = 1680
9 -- 01/22/14-14:15, TDS = 1710
+ -- 07/07/14-12:15, TDS = 1660
× -- 01/26/15-14:48, TDS = 1600
⊖ -- 07/27/15-12:35, TDS = 1780
⊠ -- 03/16/16-15:00, TDS = 1970
✳ -- 07/12/16-11:50, TDS = 1930
✱ -- 03/15/17-14:40, TDS = 2010

Percent Of Total Milliequivalents Per Liter

ALUV200 (Continued)

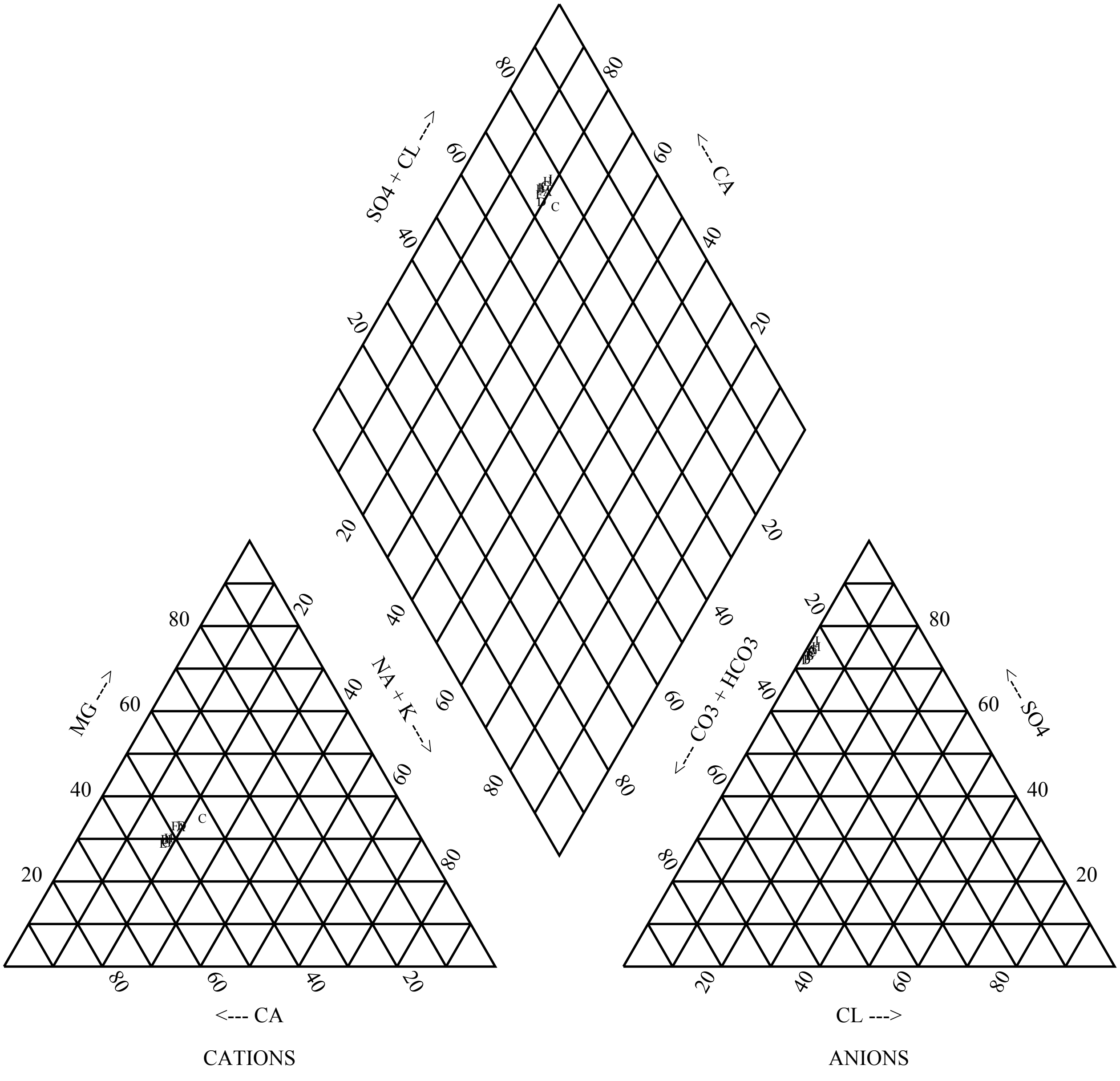
A -- 07/11/17-11:20, TDS = 1960
B -- 02/07/18-13:55, TDS = 2010
C -- 07/12/18-11:20, TDS = 1980



Percent Of Total Milliequivalents Per Liter

ALUV23

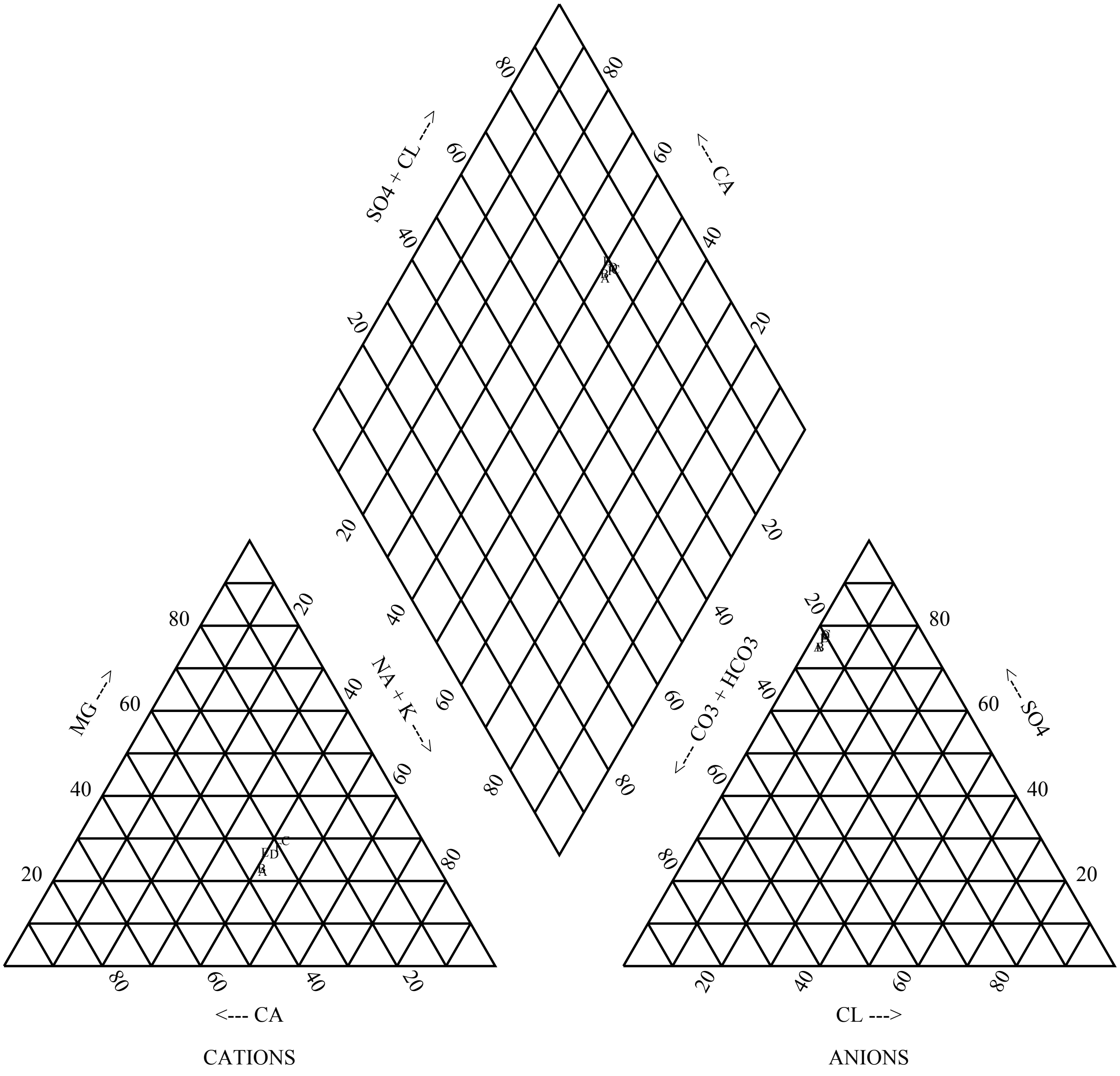
A -- 08/01/86-12:21, TDS = 1190
B -- 10/15/86-13:25, TDS = 1138
C -- 06/07/87-12:06, TDS = 1320
D -- 10/23/87-08:50, TDS = 1114
E -- 05/02/88-11:40, TDS = 996
F -- 12/22/88-13:40, TDS = 1104
G -- 03/04/91-12:10, TDS = 1106
H -- 05/13/91-12:00, TDS = 1204
I -- 08/23/91-10:10, TDS = 1312



Percent Of Total Milliequivalents Per Liter

ALUV27

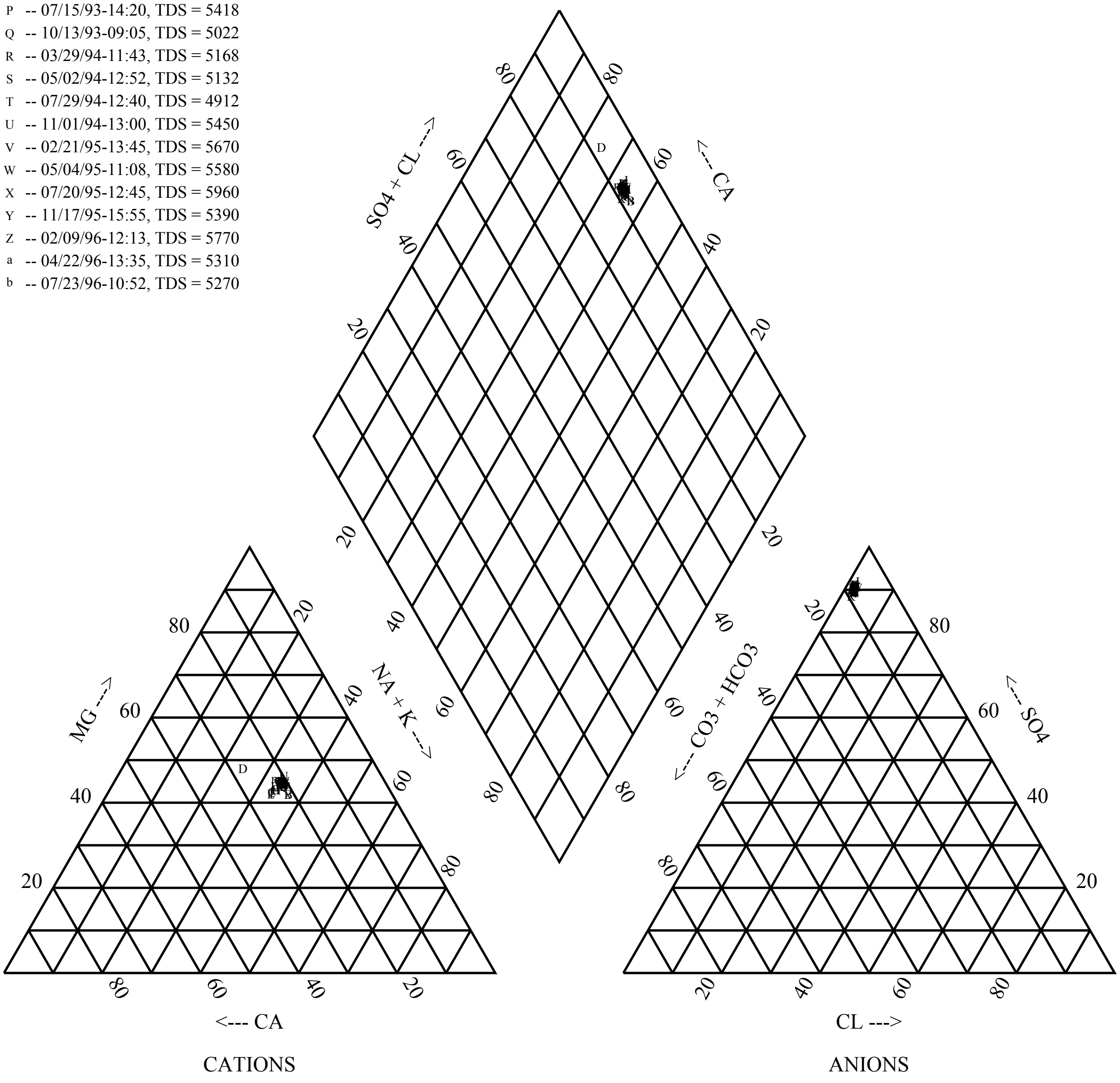
A -- 05/29/86-12:15, TDS = 1160
B -- 10/17/86-12:40, TDS = 1442
C -- 06/08/87-09:59, TDS = 1570
D -- 10/09/87-13:05, TDS = 1370
E -- 04/26/88-11:00, TDS = 1500
F -- 12/26/88-12:25, TDS = 1450



Percent Of Total Milliequivalents Per Liter

ALUV27R

A -- 06/02/89-12:00, TDS = 5514
B -- 10/03/89-13:27, TDS = 5392
C -- 05/07/90-11:00, TDS = 5055
D -- 09/11/90-11:35, TDS = 5798
E -- 12/10/90-14:12, TDS = 6950
F -- 03/08/91-09:51, TDS = 5826
G -- 05/06/91-12:02, TDS = 5674
H -- 09/16/91-11:30, TDS = 5614
I -- 12/13/91-09:20, TDS = 6002
J -- 02/21/92-11:00, TDS = 6208
K -- 05/15/92-11:44, TDS = 6042
L -- 08/21/92-10:30, TDS = 5770
M -- 10/07/92-14:15, TDS = 6034
N -- 03/11/93-16:39, TDS = 6042
O -- 05/21/93-12:30, TDS = 5462
P -- 07/15/93-14:20, TDS = 5418
Q -- 10/13/93-09:05, TDS = 5022
R -- 03/29/94-11:43, TDS = 5168
S -- 05/02/94-12:52, TDS = 5132
T -- 07/29/94-12:40, TDS = 4912
U -- 11/01/94-13:00, TDS = 5450
V -- 02/21/95-13:45, TDS = 5670
W -- 05/04/95-11:08, TDS = 5580
X -- 07/20/95-12:45, TDS = 5960
Y -- 11/17/95-15:55, TDS = 5390
Z -- 02/09/96-12:13, TDS = 5770
a -- 04/22/96-13:35, TDS = 5310
b -- 07/23/96-10:52, TDS = 5270
c -- 11/12/96-13:18, TDS = 5630
d -- 02/14/97-14:50, TDS = 5410
e -- 04/21/97-11:35, TDS = 5790
f -- 08/20/97-13:08, TDS = 5800
g -- 11/06/97-14:35, TDS = 6070
h -- 02/03/98-14:42, TDS = 5670
i -- 04/27/98-13:36, TDS = 5990
j -- 08/05/98-13:10, TDS = 6220
k -- 10/12/98-14:02, TDS = 6160
l -- 02/18/99-14:14, TDS = 6090
m -- 05/10/99-14:02, TDS = 6210
n -- 08/16/99-12:42, TDS = 6270
o -- 10/07/99-13:33, TDS = 6280
p -- 02/07/00-14:01, TDS = 6080
q -- 04/13/00-13:47, TDS = 6060
r -- 07/07/00-13:50, TDS = 6260
s -- 10/19/00-11:34, TDS = 6130
t -- 02/05/01-13:45, TDS = 6050
u -- 04/18/01-12:45, TDS = 6040
v -- 09/14/01-13:00, TDS = 6220
w -- 02/13/02-10:53, TDS = 5910
x -- 07/29/02-11:10, TDS = 6070

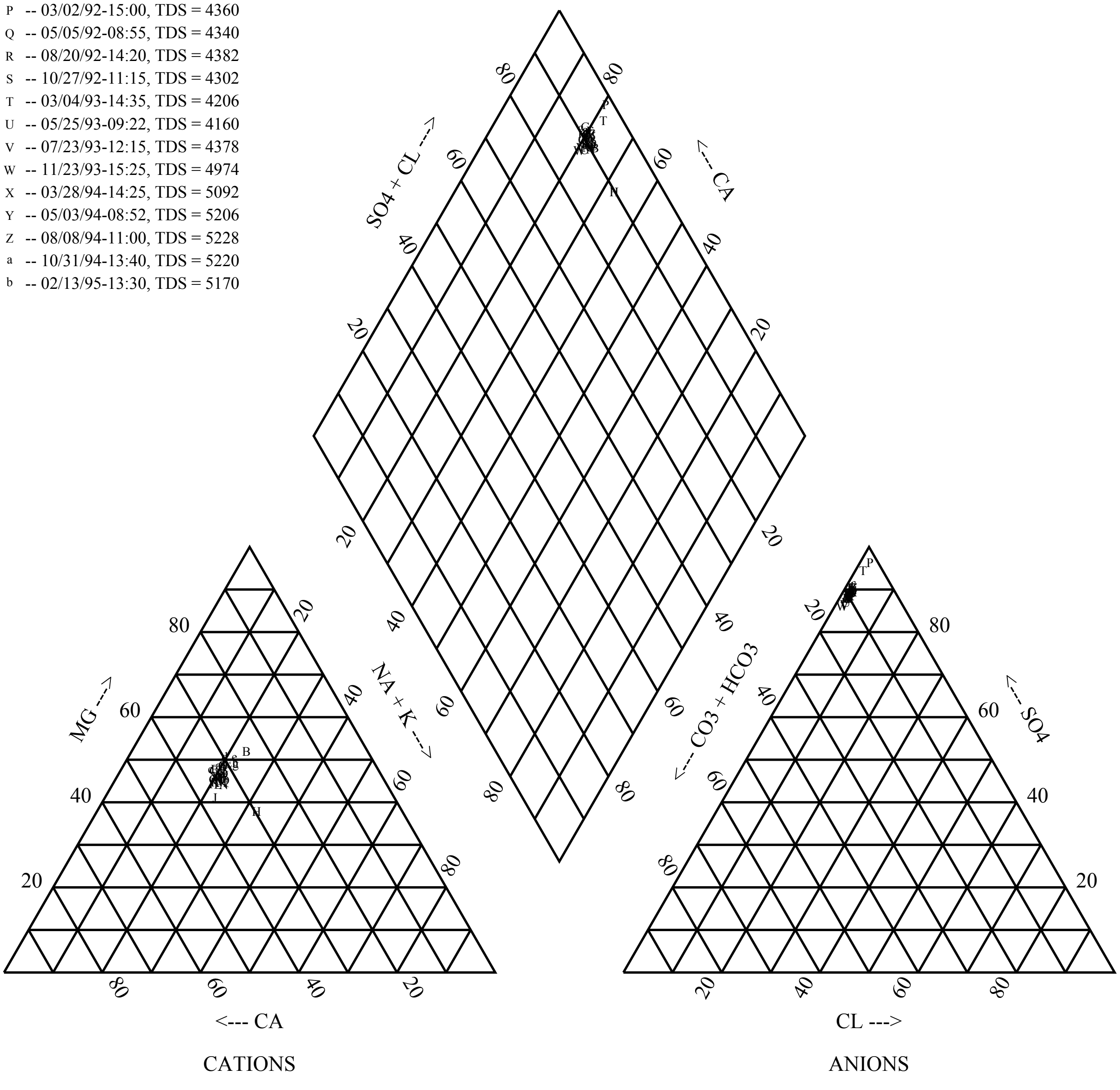


Percent Of Total Milliequivalents Per Liter

ALUV73

A -- 08/08/86-07:50, TDS = 5536
B -- 10/10/86-10:10, TDS = 6130
C -- 06/06/87-10:55, TDS = 6294
D -- 10/12/87-12:30, TDS = 5742
E -- 05/03/88-09:30, TDS = 6566
F -- 11/27/88-13:00, TDS = 4366
G -- 05/24/89-07:50, TDS = 4158
H -- 09/13/89-13:18, TDS = 4780
I -- 05/16/90-12:15, TDS = 4390
J -- 09/06/90-18:24, TDS = 4480
K -- 11/13/90-15:21, TDS = 4658
L -- 02/16/91-11:02, TDS = 4786
M -- 06/04/91-13:00, TDS = 4490
N -- 09/18/91-11:08, TDS = 4508
O -- 12/03/91-16:00, TDS = 4322
P -- 03/02/92-15:00, TDS = 4360
Q -- 05/05/92-08:55, TDS = 4340
R -- 08/20/92-14:20, TDS = 4382
S -- 10/27/92-11:15, TDS = 4302
T -- 03/04/93-14:35, TDS = 4206
U -- 05/25/93-09:22, TDS = 4160
V -- 07/23/93-12:15, TDS = 4378
W -- 11/23/93-15:25, TDS = 4974
X -- 03/28/94-14:25, TDS = 5092
Y -- 05/03/94-08:52, TDS = 5206
Z -- 08/08/94-11:00, TDS = 5228
a -- 10/31/94-13:40, TDS = 5220
b -- 02/13/95-13:30, TDS = 5170

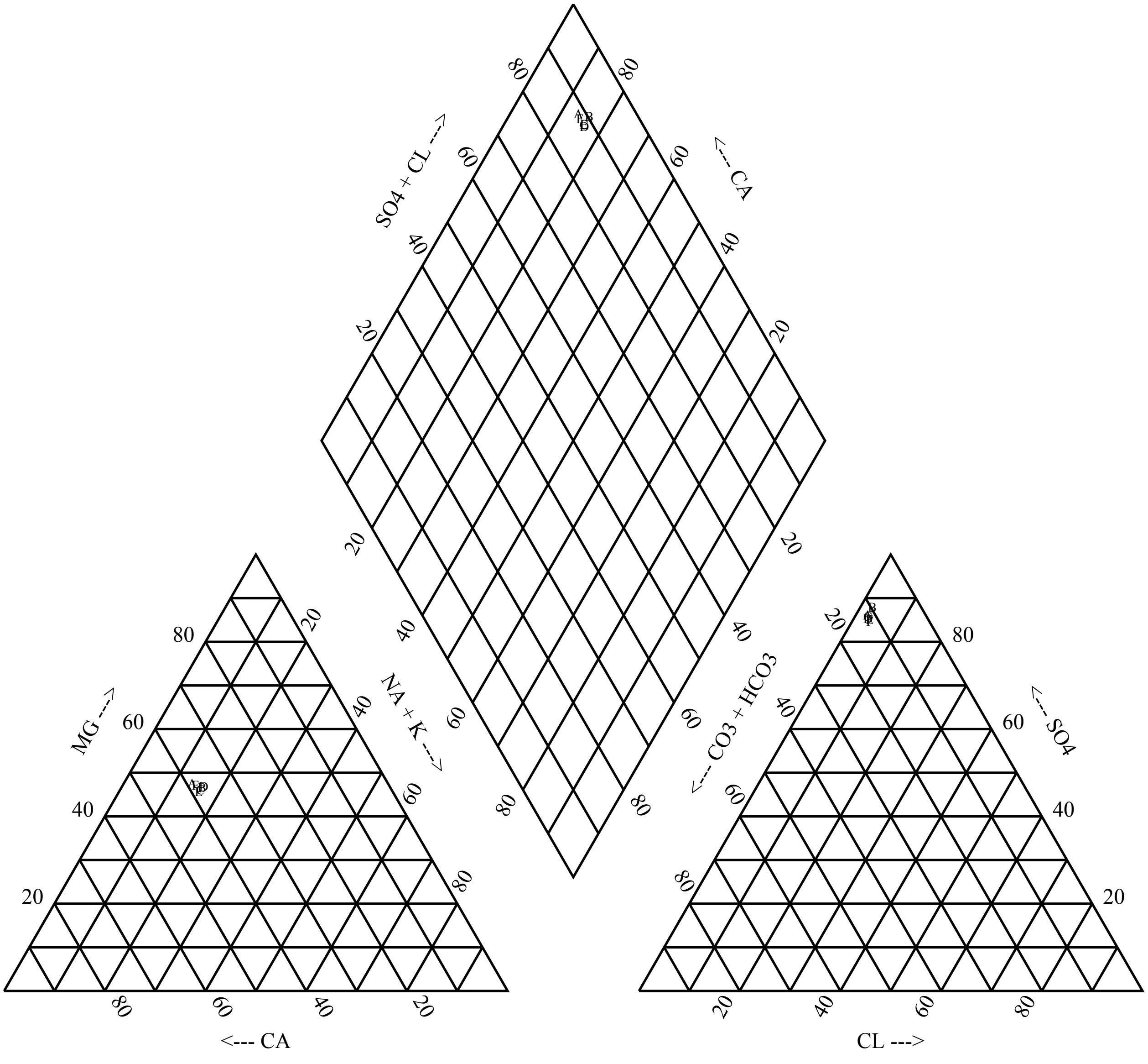
c -- 05/01/95-14:02, TDS = 4700
d -- 07/25/96-08:30, TDS = 5050
e -- 07/21/97-15:25, TDS = 6260
f -- 10/09/97-12:00, TDS = 5360
g -- 08/07/98-13:15, TDS = 5500
h -- 07/09/99-10:25, TDS = 5730
i -- 07/19/00-11:21, TDS = 4070
j -- 07/05/01-11:05, TDS = 5640



Percent Of Total Milliequivalents Per Liter

ALUV80

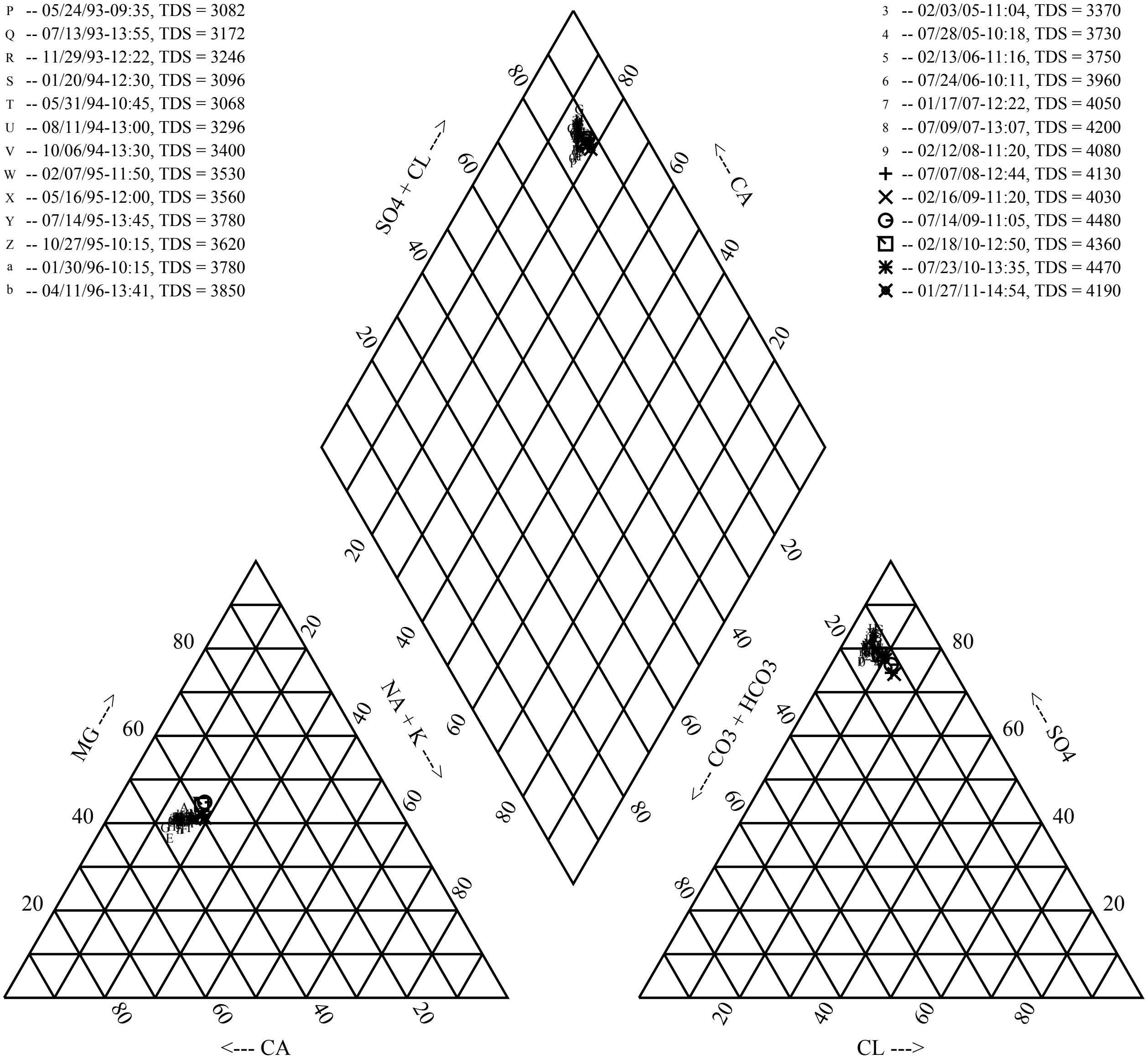
A -- 07/17/86-10:07, TDS = 3910
B -- 10/16/86-09:12, TDS = 3976
C -- 06/07/87-11:23, TDS = 3616
D -- 10/26/87-15:00, TDS = 3616
E -- 04/11/88-11:43, TDS = 3456
F -- 12/01/88-10:10, TDS = 3680



Percent Of Total Milliequivalents Per Liter

ALUV80R

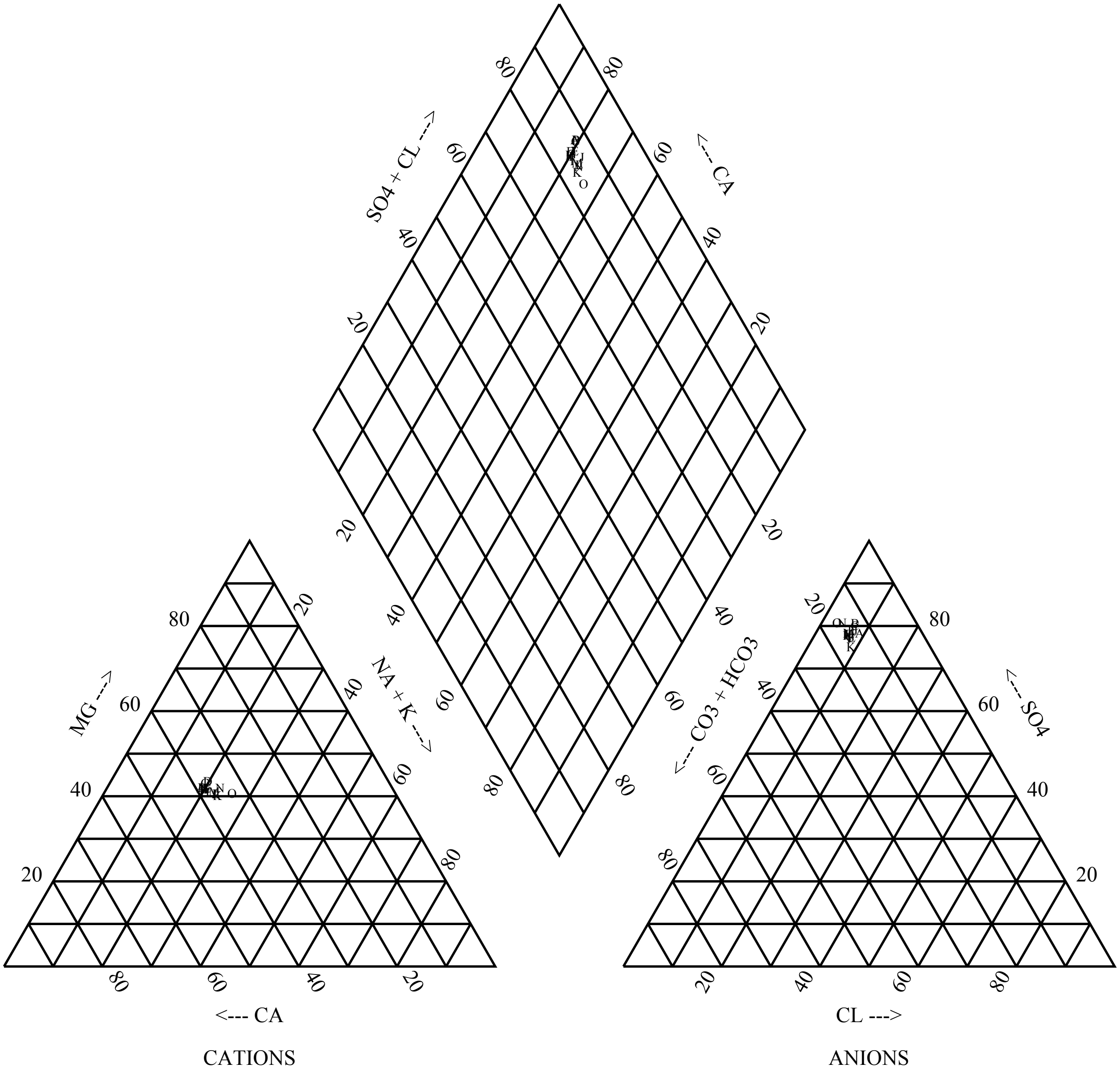
A -- 08/25/88-09:17, TDS = 2894
B -- 05/25/89-13:50, TDS = 2864
C -- 09/12/89-09:25, TDS = 2986
D -- 05/10/90-07:45, TDS = 3122
E -- 09/07/90-11:05, TDS = 3164
F -- 12/05/90-14:50, TDS = 3452
G -- 02/07/91-10:15, TDS = 3368
H -- 05/15/91-11:40, TDS = 3324
I -- 08/14/91-15:56, TDS = 3330
J -- 11/21/91-15:35, TDS = 3370
K -- 02/27/92-09:38, TDS = 3330
L -- 04/23/92-08:37, TDS = 3356
M -- 07/23/92-10:37, TDS = 3308
N -- 11/19/92-12:58, TDS = 3118
O -- 02/12/93-14:40, TDS = 3024
P -- 05/24/93-09:35, TDS = 3082
Q -- 07/13/93-13:55, TDS = 3172
R -- 11/29/93-12:22, TDS = 3246
S -- 01/20/94-12:30, TDS = 3096
T -- 05/31/94-10:45, TDS = 3068
U -- 08/11/94-13:00, TDS = 3296
V -- 10/06/94-13:30, TDS = 3400
W -- 02/07/95-11:50, TDS = 3530
X -- 05/16/95-12:00, TDS = 3560
Y -- 07/14/95-13:45, TDS = 3780
Z -- 10/27/95-10:15, TDS = 3620
a -- 01/30/96-10:15, TDS = 3780
b -- 04/11/96-13:41, TDS = 3850
c -- 07/15/96-11:00, TDS = 3840
d -- 10/30/96-13:18, TDS = 3940
e -- 02/04/97-12:33, TDS = 3920
f -- 04/15/97-12:31, TDS = 4000
g -- 09/04/97-12:07, TDS = 3930
h -- 10/23/97-13:08, TDS = 3750
i -- 03/02/98-14:05, TDS = 3970
j -- 04/22/98-12:41, TDS = 4010
k -- 07/20/98-12:00, TDS = 4050
l -- 10/09/98-10:32, TDS = 3910
m -- 02/12/99-15:08, TDS = 3770
n -- 04/19/99-13:50, TDS = 3770
o -- 07/19/99-14:25, TDS = 4030
p -- 10/14/99-13:15, TDS = 3620
q -- 01/13/00-10:00, TDS = 3500
r -- 04/10/00-10:21, TDS = 3580
s -- 08/02/00-13:56, TDS = 3480
t -- 10/04/00-12:20, TDS = 3550
u -- 01/08/01-14:00, TDS = 3500
v -- 04/09/01-13:15, TDS = 3480
w -- 07/19/01-11:20, TDS = 3580
x -- 01/17/02-12:22, TDS = 3640
y -- 07/31/02-11:10, TDS = 4080
z -- 02/19/03-09:28, TDS = 3590
0 -- 07/21/03-13:03, TDS = 3670
1 -- 01/26/04-13:05, TDS = 3490
2 -- 07/12/04-10:35, TDS = 3580
3 -- 02/03/05-11:04, TDS = 3370
4 -- 07/28/05-10:18, TDS = 3730
5 -- 02/13/06-11:16, TDS = 3750
6 -- 07/24/06-10:11, TDS = 3960
7 -- 01/17/07-12:22, TDS = 4050
8 -- 07/09/07-13:07, TDS = 4200
9 -- 02/12/08-11:20, TDS = 4080
+ -- 07/07/08-12:44, TDS = 4130
× -- 02/16/09-11:20, TDS = 4030
⊖ -- 07/14/09-11:05, TDS = 4480
⧄ -- 02/18/10-12:50, TDS = 4360
✳ -- 07/23/10-13:35, TDS = 4470
✖ -- 01/27/11-14:54, TDS = 4190



Percent Of Total Milliequivalents Per Liter

ALUV80R (Continued)

A	-- 07/13/11-13:50, TDS = 4270
B	-- 01/10/12-12:30, TDS = 4170
C	-- 07/25/12-09:15, TDS = 4020
D	-- 02/18/13-16:10, TDS = 3930
E	-- 07/15/13-12:40, TDS = 3890
F	-- 01/27/14-14:18, TDS = 3870
G	-- 07/10/14-13:25, TDS = 3980
H	-- 01/27/15-16:50, TDS = 4260
I	-- 08/17/15-12:40, TDS = 4590
J	-- 03/10/16-13:00, TDS = 4850
K	-- 07/12/16-10:20, TDS = 4600
L	-- 02/21/17-12:44, TDS = 4560
M	-- 07/10/17-12:00, TDS = 5600
N	-- 02/05/18-13:30, TDS = 5060
O	-- 07/11/18-13:05, TDS = 5520



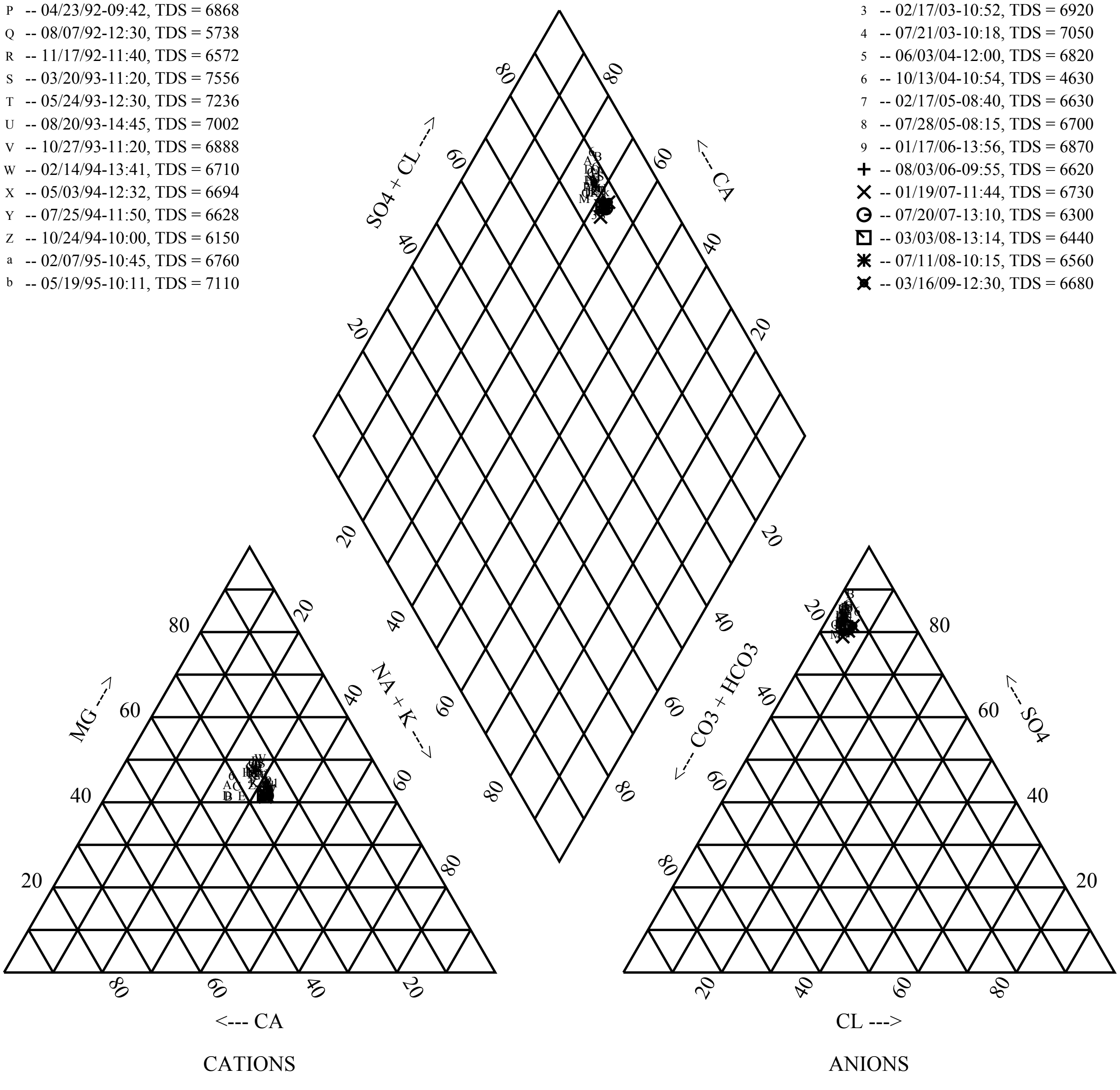
Percent Of Total Milliequivalents Per Liter

ALUV83

A -- 07/17/86-09:00, TDS = 6518
B -- 10/16/86-11:20, TDS = 6784
C -- 06/08/87-08:55, TDS = 6892
D -- 10/23/87-14:15, TDS = 7048
E -- 04/11/88-10:38, TDS = 7594
F -- 12/12/88-13:50, TDS = 7196
G -- 05/26/89-10:20, TDS = 7234
H -- 09/14/89-12:10, TDS = 7412
I -- 05/09/90-10:55, TDS = 6938
J -- 11/14/90-12:55, TDS = 7028
K -- 03/12/91-11:55, TDS = 7448
L -- 05/15/91-09:50, TDS = 7300
M -- 08/14/91-13:29, TDS = 5870
N -- 11/25/91-13:50, TDS = 6516
O -- 01/30/92-13:30, TDS = 6756
P -- 04/23/92-09:42, TDS = 6868
Q -- 08/07/92-12:30, TDS = 5738
R -- 11/17/92-11:40, TDS = 6572
S -- 03/20/93-11:20, TDS = 7556
T -- 05/24/93-12:30, TDS = 7236
U -- 08/20/93-14:45, TDS = 7002
V -- 10/27/93-11:20, TDS = 6888
W -- 02/14/94-13:41, TDS = 6710
X -- 05/03/94-12:32, TDS = 6694
Y -- 07/25/94-11:50, TDS = 6628
Z -- 10/24/94-10:00, TDS = 6150
a -- 02/07/95-10:45, TDS = 6760
b -- 05/19/95-10:11, TDS = 7110

c -- 07/25/95-11:25, TDS = 6230
d -- 10/30/95-13:55, TDS = 6230
e -- 01/24/96-14:40, TDS = 6690
f -- 04/15/96-14:01, TDS = 6900
g -- 07/16/96-12:10, TDS = 6510
h -- 11/01/96-13:05, TDS = 6600
i -- 02/11/97-10:36, TDS = 6440
j -- 04/15/97-11:22, TDS = 7180
k -- 07/10/97-08:59, TDS = 7390
l -- 10/23/97-10:40, TDS = 6920
m -- 01/19/98-10:48, TDS = 7670
n -- 04/20/98-09:20, TDS = 7650

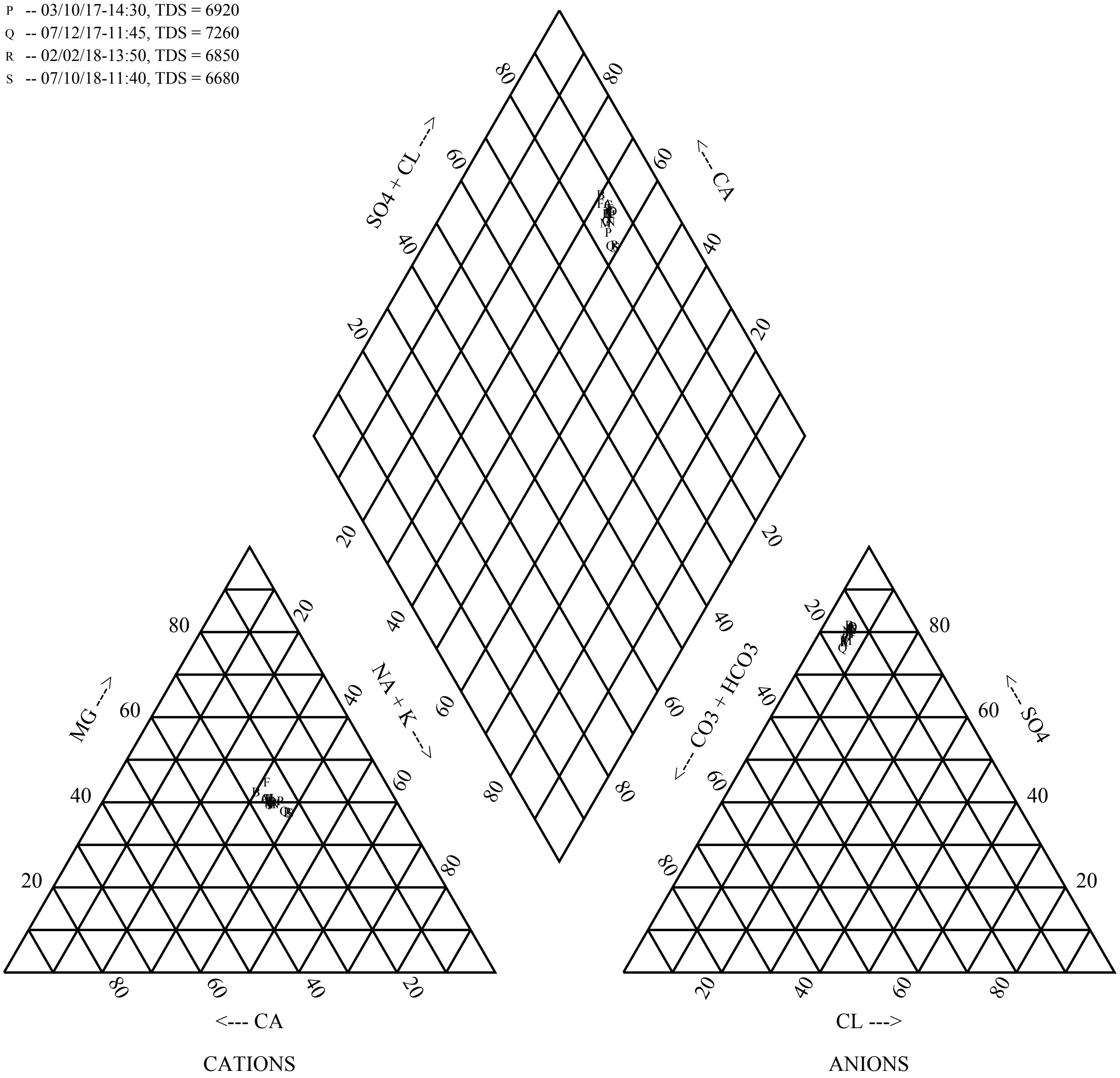
o -- 07/17/98-11:12, TDS = 7650
p -- 10/08/98-11:51, TDS = 7590
q -- 02/09/99-13:00, TDS = 7550
r -- 04/26/99-11:15, TDS = 7660
s -- 07/22/99-09:15, TDS = 7630
t -- 10/14/99-09:40, TDS = 6990
u -- 01/14/00-10:05, TDS = 7180
v -- 04/05/00-13:35, TDS = 7210
w -- 07/27/00-11:29, TDS = 7110
x -- 10/18/00-09:00, TDS = 6720
y -- 01/19/01-11:20, TDS = 6910
z -- 04/24/01-14:08, TDS = 7020
0 -- 07/18/01-11:50, TDS = 7200
1 -- 01/17/02-10:50, TDS = 6950
2 -- 07/31/02-10:26, TDS = 7110
3 -- 02/17/03-10:52, TDS = 6920
4 -- 07/21/03-10:18, TDS = 7050
5 -- 06/03/04-12:00, TDS = 6820
6 -- 10/13/04-10:54, TDS = 4630
7 -- 02/17/05-08:40, TDS = 6630
8 -- 07/28/05-08:15, TDS = 6700
9 -- 01/17/06-13:56, TDS = 6870
+ -- 08/03/06-09:55, TDS = 6620
× -- 01/19/07-11:44, TDS = 6730
⊖ -- 07/20/07-13:10, TDS = 6300
☐ -- 03/03/08-13:14, TDS = 6440
✳ -- 07/11/08-10:15, TDS = 6560
✖ -- 03/16/09-12:30, TDS = 6680



Percent Of Total Milliequivalents Per Liter

ALUV83 (Continued)

A -- 07/22/09-10:15, TDS = 7080
B -- 03/22/10-11:40, TDS = 7100
C -- 08/13/10-11:50, TDS = 7020
D -- 02/15/11-13:50, TDS = 7210
E -- 07/12/11-15:20, TDS = 7290
F -- 02/22/12-13:40, TDS = 7180
G -- 08/17/12-13:00, TDS = 6900
H -- 03/04/13-11:50, TDS = 7010
I -- 07/19/13-13:30, TDS = 6390
J -- 01/15/14-13:50, TDS = 7360
K -- 07/08/14-10:06, TDS = 5680
L -- 01/22/15-12:12, TDS = 7420
M -- 08/17/15-11:11, TDS = 10400
N -- 03/04/16-12:00, TDS = 7370
O -- 09/14/16-12:25, TDS = 5620
P -- 03/10/17-14:30, TDS = 6920
Q -- 07/12/17-11:45, TDS = 7260
R -- 02/02/18-13:50, TDS = 6850
S -- 07/10/18-11:40, TDS = 6680



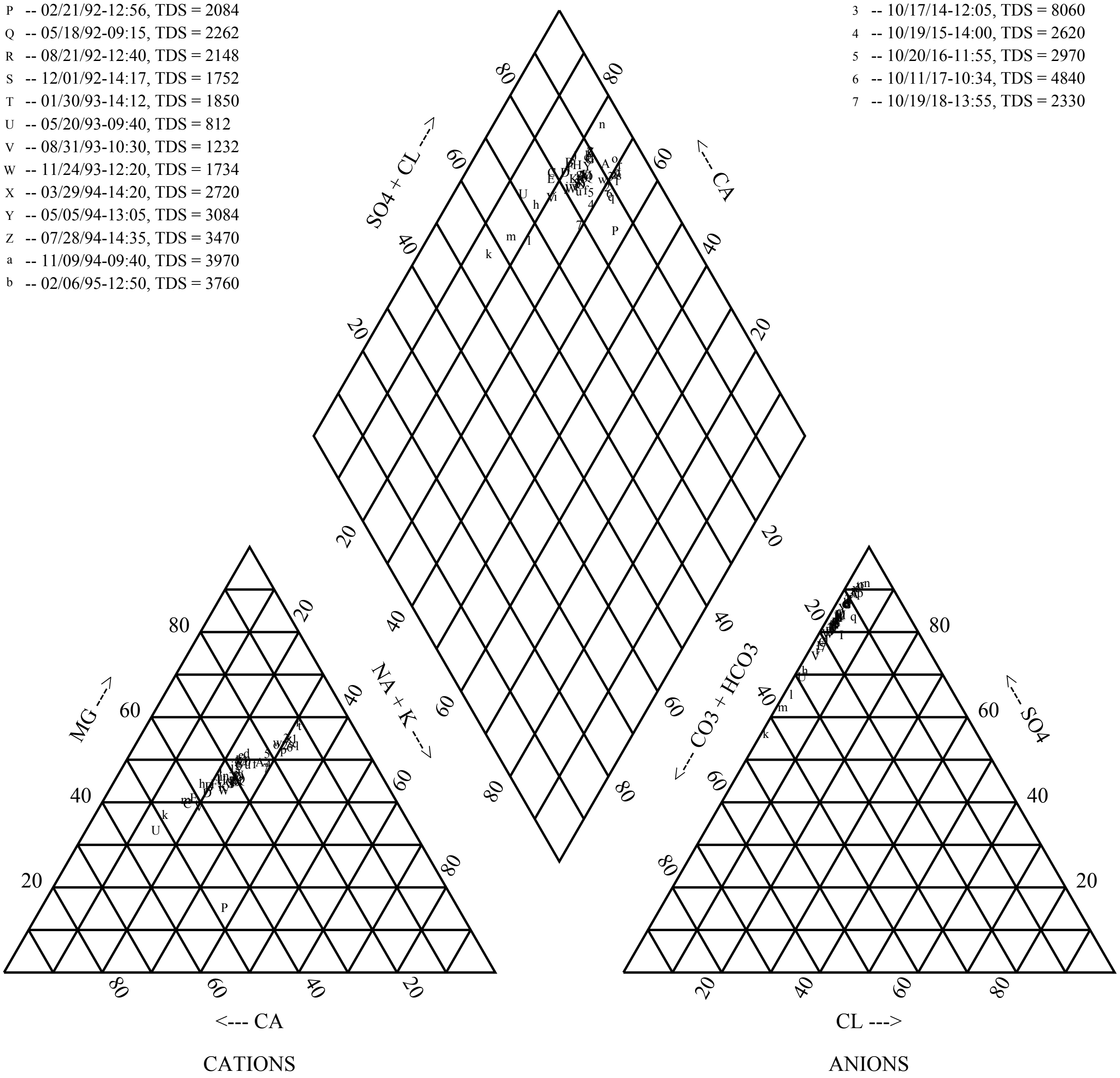
Percent Of Total Milliequivalents Per Liter

ALUV87

A -- 07/31/86-11:40, TDS = 4908
B -- 10/15/86-12:59, TDS = 1602
C -- 06/07/87-12:31, TDS = 1352
D -- 10/23/87-08:10, TDS = 1616
E -- 03/08/88-15:20, TDS = 1212
F -- 12/22/88-14:30, TDS = 1680
G -- 05/26/89-08:20, TDS = 2364
H -- 09/29/89-10:45, TDS = 2136
I -- 05/09/90-08:10, TDS = 2312
J -- 09/17/90-10:25, TDS = 2126
K -- 11/19/90-10:12, TDS = 1940
L -- 03/04/91-13:27, TDS = 2292
M -- 05/13/91-13:20, TDS = 2296
N -- 09/17/91-14:50, TDS = 2200
O -- 12/12/91-10:58, TDS = 2120
P -- 02/21/92-12:56, TDS = 2084
Q -- 05/18/92-09:15, TDS = 2262
R -- 08/21/92-12:40, TDS = 2148
S -- 12/01/92-14:17, TDS = 1752
T -- 01/30/93-14:12, TDS = 1850
U -- 05/20/93-09:40, TDS = 812
V -- 08/31/93-10:30, TDS = 1232
W -- 11/24/93-12:20, TDS = 1734
X -- 03/29/94-14:20, TDS = 2720
Y -- 05/05/94-13:05, TDS = 3084
Z -- 07/28/94-14:35, TDS = 3470
a -- 11/09/94-09:40, TDS = 3970
b -- 02/06/95-12:50, TDS = 3760

c -- 05/09/95-08:46, TDS = 3890
d -- 07/24/96-08:15, TDS = 3810
e -- 07/11/97-11:10, TDS = 3360
f -- 10/09/97-14:25, TDS = 2280
g -- 07/27/98-10:55, TDS = 2530
h -- 07/06/99-10:36, TDS = 1420
i -- 07/04/00-11:15, TDS = 1280
j -- 07/19/01-13:00, TDS = 1900
k -- 07/25/02-09:05, TDS = 820
l -- 05/09/03-09:35, TDS = 1280
m -- 07/19/04-13:44, TDS = 1000
n -- 11/02/05-10:45, TDS = 8200

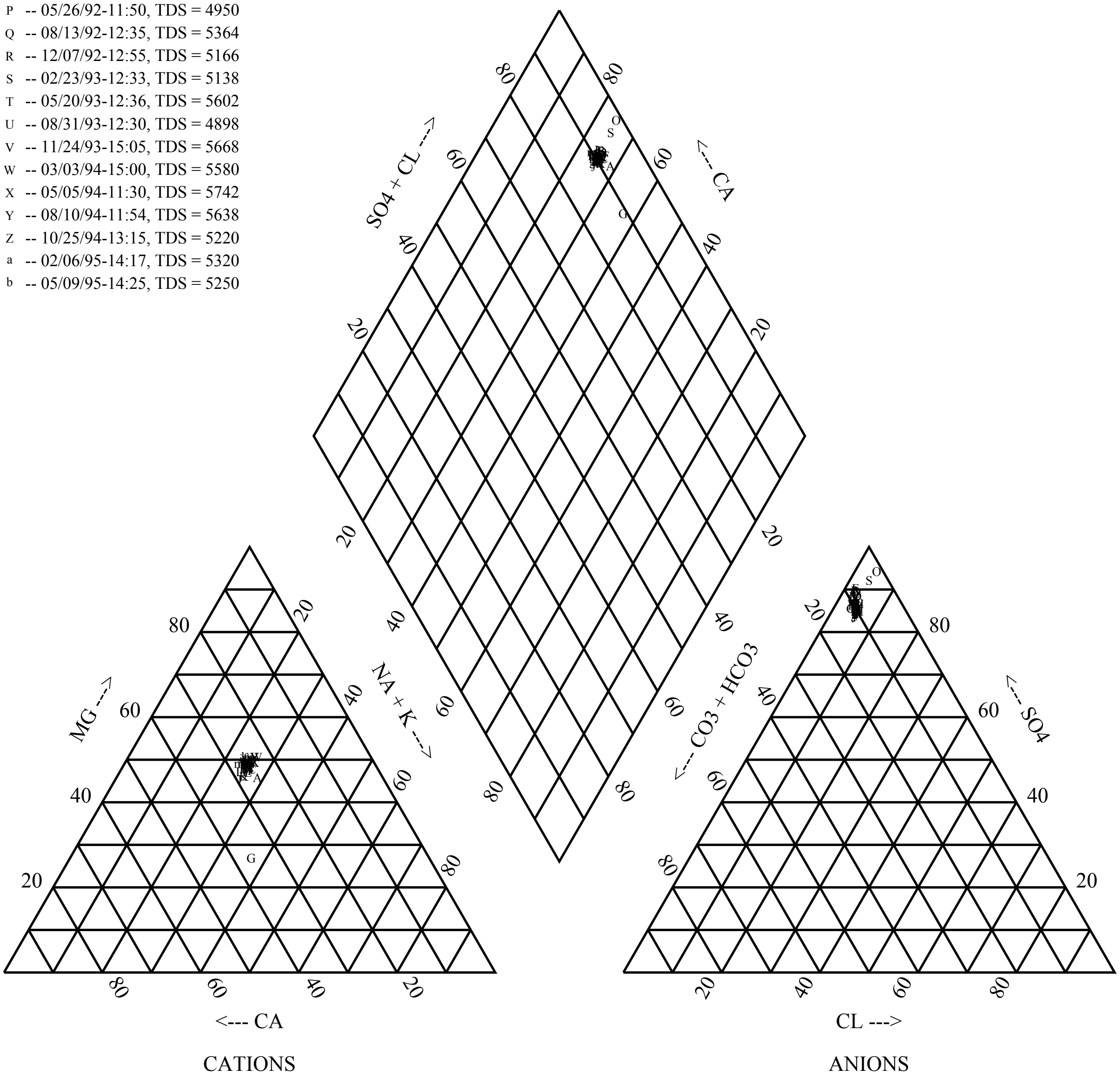
o -- 12/16/05-12:15, TDS = 11700
p -- 05/03/06-12:08, TDS = 9430
q -- 10/18/06-13:20, TDS = 14500
r -- 03/13/07-09:58, TDS = 15100
s -- 09/18/07-13:27, TDS = 11300
t -- 02/12/08-10:35, TDS = 13400
u -- 10/24/08-13:05, TDS = 2560
v -- 03/18/09-15:32, TDS = 4620
w -- 07/15/09-15:45, TDS = 4840
x -- 05/12/10-15:20, TDS = 9900
y -- 11/03/10-15:12, TDS = 2470
z -- 03/30/11-15:00, TDS = 8340
0 -- 10/24/11-12:57, TDS = 2400
1 -- 07/31/12-13:00, TDS = 8360
2 -- 10/08/13-13:00, TDS = 4720
3 -- 10/17/14-12:05, TDS = 8060
4 -- 10/19/15-14:00, TDS = 2620
5 -- 10/20/16-11:55, TDS = 2970
6 -- 10/11/17-10:34, TDS = 4840
7 -- 10/19/18-13:55, TDS = 2330



Percent Of Total Milliequivalents Per Liter

ALUV88

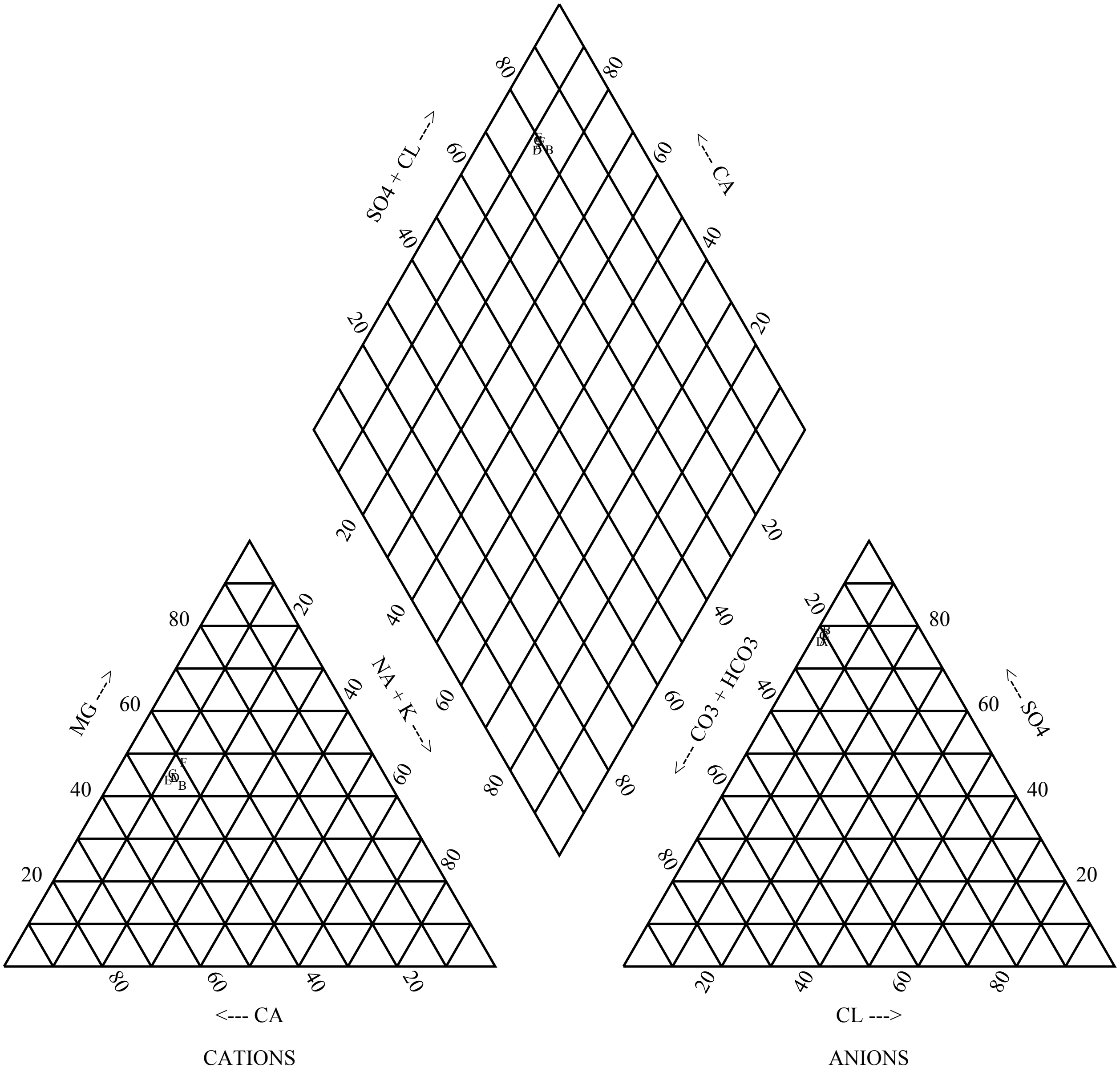
A -- 08/01/86-12:54, TDS = 5108
B -- 10/16/86-08:12, TDS = 5242
C -- 06/07/87-13:04, TDS = 4940
D -- 10/23/87-09:25, TDS = 5152
E -- 03/08/88-15:55, TDS = 5032
F -- 12/22/88-12:24, TDS = 5248
G -- 12/04/89-14:30, TDS = 5496
H -- 05/09/90-09:10, TDS = 5498
I -- 09/11/90-14:13, TDS = 5454
J -- 11/19/90-14:45, TDS = 5492
K -- 03/04/91-10:40, TDS = 5428
L -- 05/13/91-10:50, TDS = 5082
M -- 08/22/91-10:00, TDS = 5450
N -- 12/02/91-13:30, TDS = 4306
O -- 03/03/92-11:35, TDS = 5150
P -- 05/26/92-11:50, TDS = 4950
Q -- 08/13/92-12:35, TDS = 5364
R -- 12/07/92-12:55, TDS = 5166
S -- 02/23/93-12:33, TDS = 5138
T -- 05/20/93-12:36, TDS = 5602
U -- 08/31/93-12:30, TDS = 4898
V -- 11/24/93-15:05, TDS = 5668
W -- 03/03/94-15:00, TDS = 5580
X -- 05/05/94-11:30, TDS = 5742
Y -- 08/10/94-11:54, TDS = 5638
Z -- 10/25/94-13:15, TDS = 5220
a -- 02/06/95-14:17, TDS = 5320
b -- 05/09/95-14:25, TDS = 5250
c -- 07/27/95-14:35, TDS = 5170
d -- 11/03/95-12:15, TDS = 4960
e -- 02/06/96-11:45, TDS = 4850
f -- 04/19/96-11:50, TDS = 4840
g -- 07/17/96-13:35, TDS = 4880
h -- 10/31/96-15:10, TDS = 4940
i -- 02/10/97-13:45, TDS = 4980
j -- 04/16/97-12:30, TDS = 5050
k -- 07/11/97-12:40, TDS = 5380
l -- 11/20/97-13:20, TDS = 4900
m -- 03/02/98-13:00, TDS = 5100
n -- 04/23/98-11:50, TDS = 5250
o -- 08/19/98-14:53, TDS = 5430
p -- 10/14/98-15:07, TDS = 5570
q -- 02/12/99-13:30, TDS = 5740
r -- 05/06/99-11:30, TDS = 6130
s -- 08/24/99-11:35, TDS = 6050
t -- 10/27/99-14:07, TDS = 5800
u -- 01/13/00-13:40, TDS = 5810
v -- 04/10/00-13:45, TDS = 6010
w -- 07/28/00-13:56, TDS = 6110
x -- 10/17/00-13:42, TDS = 6090
y -- 01/25/01-10:47, TDS = 6080
z -- 04/19/01-12:30, TDS = 5940



Percent Of Total Milliequivalents Per Liter

ALUV89

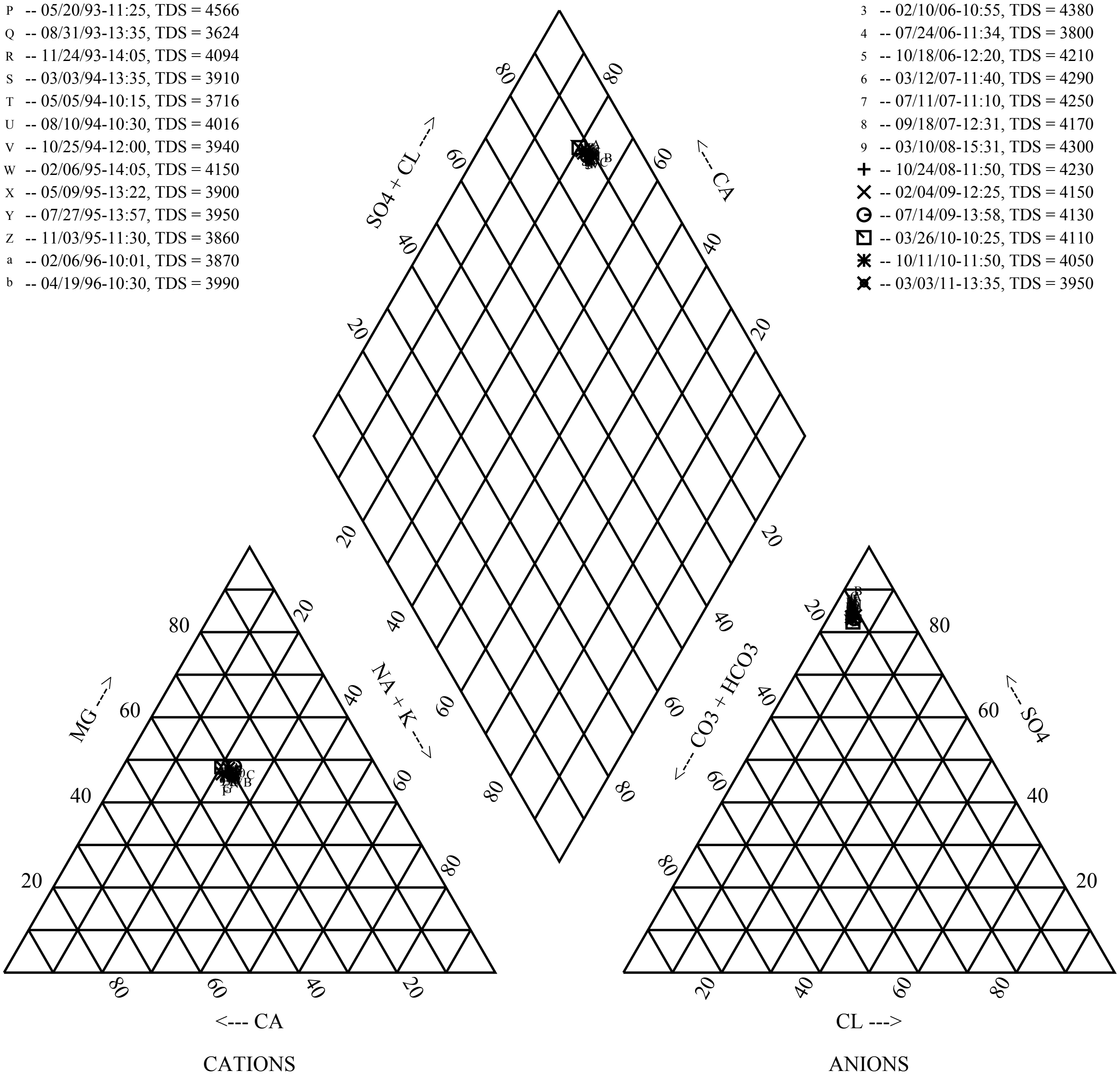
A -- 08/01/86-13:18, TDS = 1682
B -- 10/16/86-08:35, TDS = 1990
C -- 06/07/87-13:20, TDS = 1600
D -- 10/23/87-10:00, TDS = 1580
E -- 05/02/88-12:25, TDS = 1618
F -- 12/22/88-11:15, TDS = 1700



Percent Of Total Milliequivalents Per Liter

ALUV89R

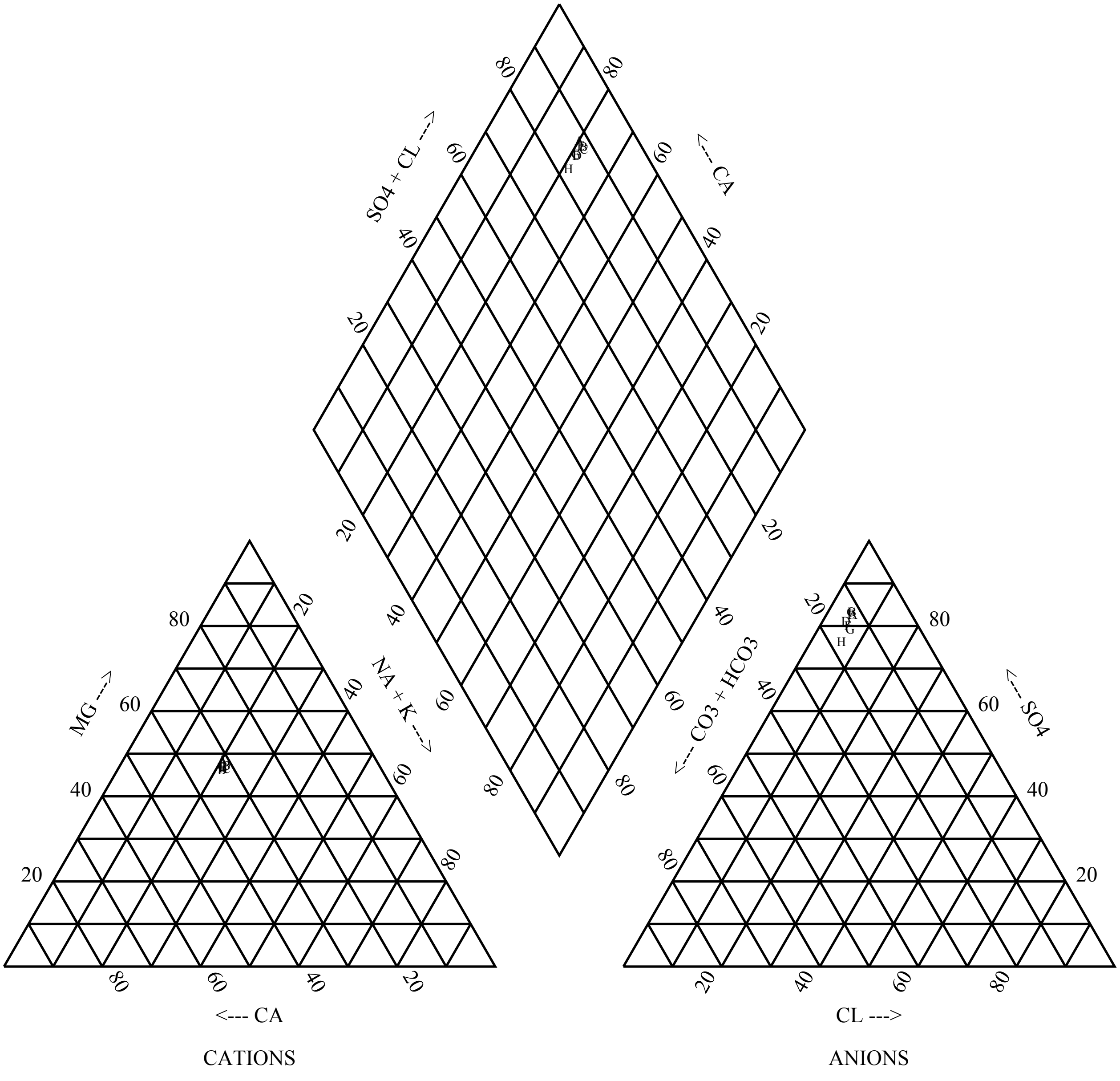
A -- 12/22/88-12:00, TDS = 4490
B -- 05/26/89-09:25, TDS = 4126
C -- 09/29/89-09:50, TDS = 4164
D -- 05/09/90-08:50, TDS = 4186
E -- 09/11/90-12:58, TDS = 4228
F -- 11/19/90-14:11, TDS = 4140
G -- 03/04/91-09:56, TDS = 4028
H -- 05/13/91-10:00, TDS = 3850
I -- 08/22/91-08:55, TDS = 4014
J -- 12/02/91-12:27, TDS = 3760
K -- 03/03/92-10:30, TDS = 3830
L -- 05/26/92-10:22, TDS = 3758
M -- 08/13/92-11:15, TDS = 3986
N -- 12/07/92-11:51, TDS = 3926
O -- 02/23/93-11:34, TDS = 4064
P -- 05/20/93-11:25, TDS = 4566
Q -- 08/31/93-13:35, TDS = 3624
R -- 11/24/93-14:05, TDS = 4094
S -- 03/03/94-13:35, TDS = 3910
T -- 05/05/94-10:15, TDS = 3716
U -- 08/10/94-10:30, TDS = 4016
V -- 10/25/94-12:00, TDS = 3940
W -- 02/06/95-14:05, TDS = 4150
X -- 05/09/95-13:22, TDS = 3900
Y -- 07/27/95-13:57, TDS = 3950
Z -- 11/03/95-11:30, TDS = 3860
a -- 02/06/96-10:01, TDS = 3870
b -- 04/19/96-10:30, TDS = 3990
c -- 07/17/96-11:35, TDS = 4050
d -- 10/31/96-14:00, TDS = 4040
e -- 02/10/97-12:10, TDS = 3940
f -- 04/16/97-12:15, TDS = 4170
g -- 07/11/97-12:27, TDS = 4330
h -- 11/20/97-12:35, TDS = 3720
i -- 03/02/98-11:34, TDS = 4060
j -- 04/23/98-11:15, TDS = 4300
k -- 08/19/98-14:17, TDS = 4090
l -- 10/14/98-14:32, TDS = 4240
m -- 02/12/99-13:15, TDS = 4560
n -- 05/06/99-09:45, TDS = 4690
o -- 08/24/99-10:50, TDS = 4480
p -- 10/27/99-13:20, TDS = 4480
q -- 01/13/00-12:50, TDS = 4670
r -- 04/10/00-12:55, TDS = 4760
s -- 07/28/00-13:13, TDS = 4480
t -- 10/17/00-14:00, TDS = 4630
u -- 01/25/01-10:36, TDS = 4760
v -- 04/19/01-11:46, TDS = 4460
w -- 07/25/02-12:30, TDS = 4720
x -- 11/06/03-13:22, TDS = 4390
y -- 06/03/04-14:08, TDS = 4550
z -- 01/27/05-12:45, TDS = 4430
0 -- 04/15/05-09:23, TDS = 5510
1 -- 07/21/05-08:04, TDS = 3430
2 -- 10/20/05-11:40, TDS = 4380
3 -- 02/10/06-10:55, TDS = 4380
4 -- 07/24/06-11:34, TDS = 3800
5 -- 10/18/06-12:20, TDS = 4210
6 -- 03/12/07-11:40, TDS = 4290
7 -- 07/11/07-11:10, TDS = 4250
8 -- 09/18/07-12:31, TDS = 4170
9 -- 03/10/08-15:31, TDS = 4300
+ -- 10/24/08-11:50, TDS = 4230
× -- 02/04/09-12:25, TDS = 4150
⊖ -- 07/14/09-13:58, TDS = 4130
⧄ -- 03/26/10-10:25, TDS = 4110
✳ -- 10/11/10-11:50, TDS = 4050
⧖ -- 03/03/11-13:35, TDS = 3950



Percent Of Total Milliequivalents Per Liter

ALUV89R (Continued)

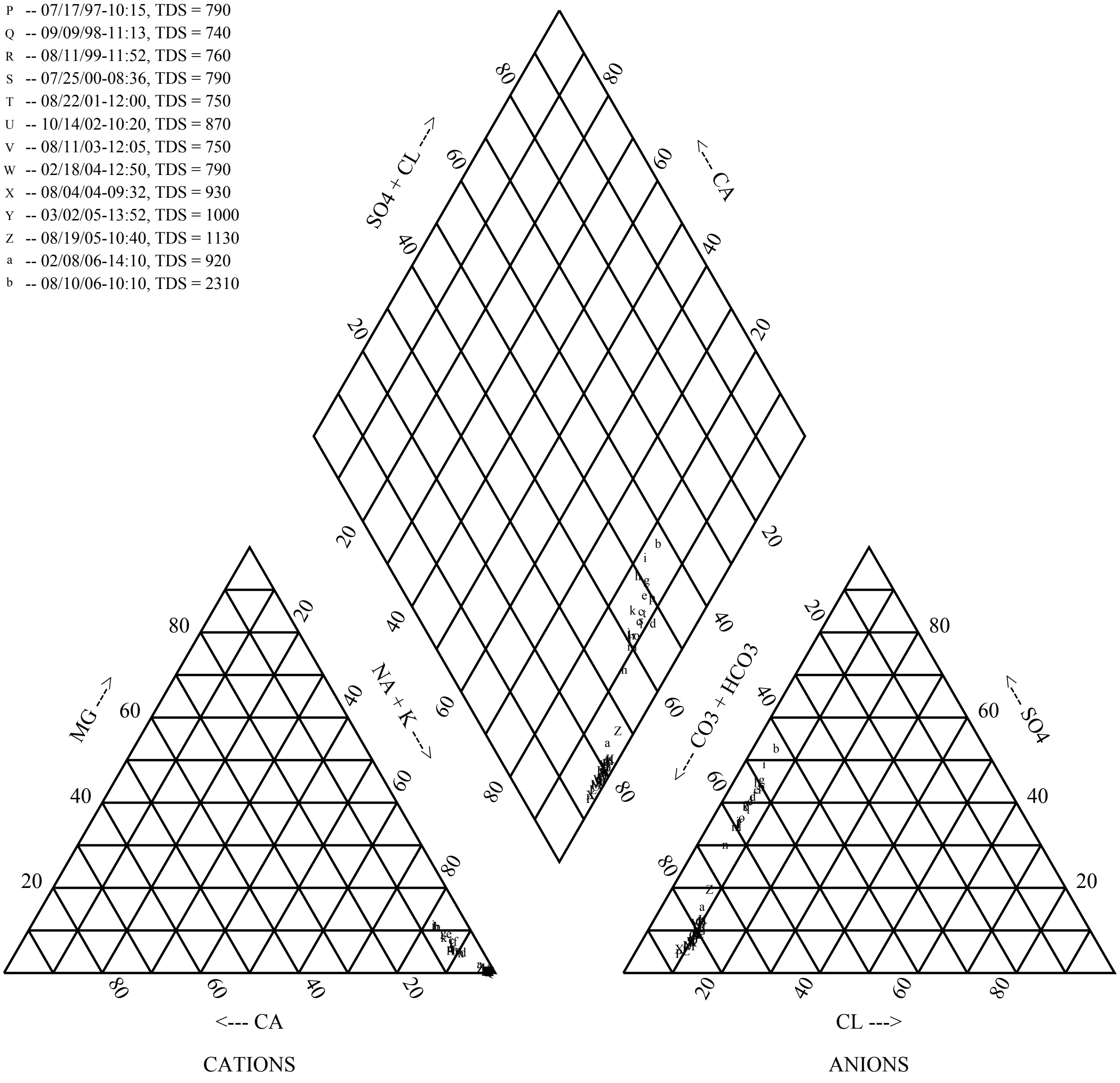
A -- 10/24/11-14:10, TDS = 3860
B -- 07/24/12-14:45, TDS = 3780
C -- 05/01/13-14:32, TDS = 3790
D -- 07/14/14-11:20, TDS = 3740
E -- 10/19/15-12:45, TDS = 3700
F -- 07/13/16-13:40, TDS = 3760
G -- 07/06/17-14:35, TDS = 3640
H -- 10/19/18-13:15, TDS = 3580



Percent Of Total Milliequivalents Per Liter

WEPO40

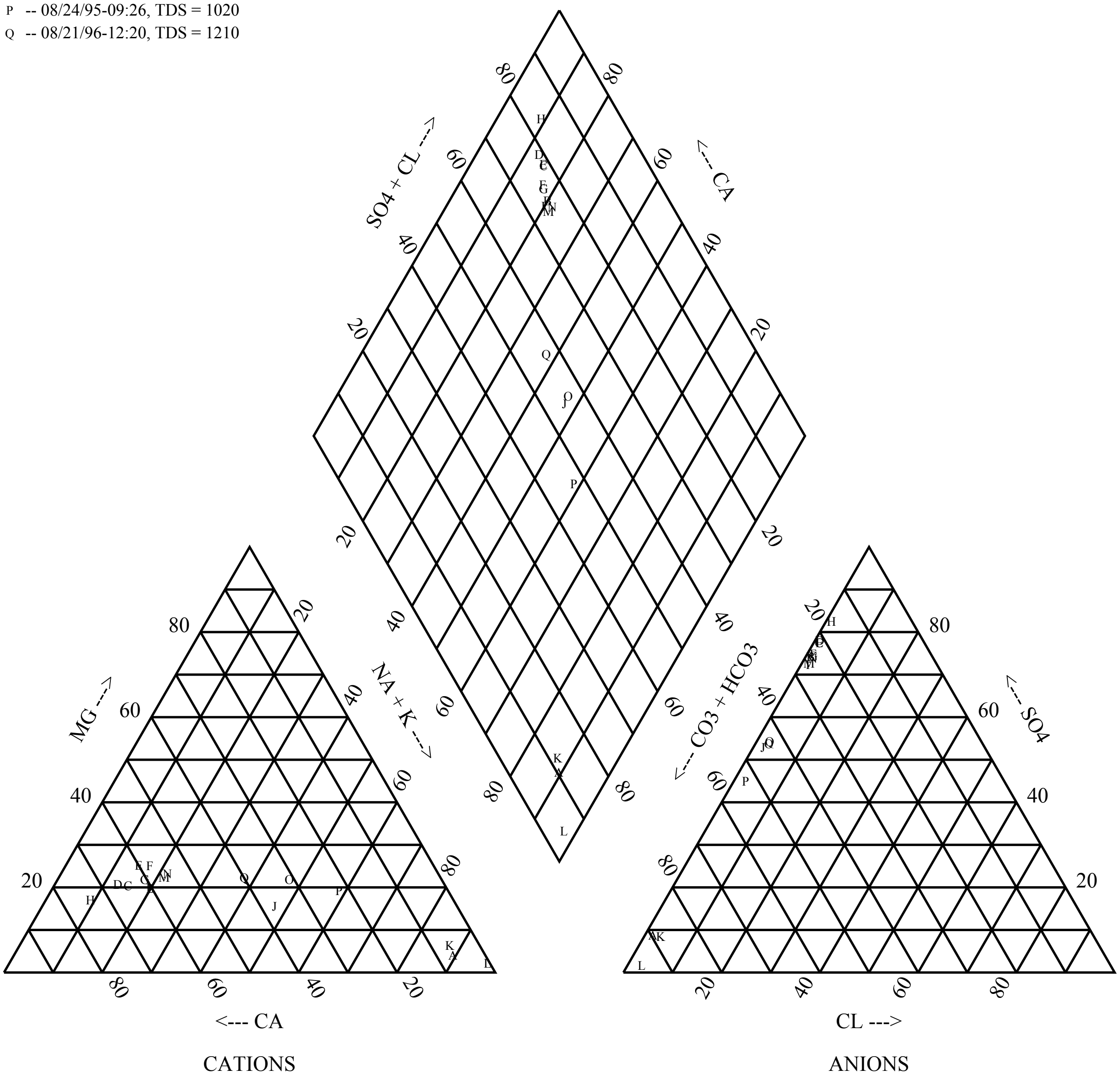
A -- 04/23/86-14:12, TDS = 728
B -- 10/24/86-10:10, TDS = 750
C -- 06/09/87-11:35, TDS = 746
D -- 10/23/87-08:03, TDS = 756
E -- 04/27/88-11:10, TDS = 762
F -- 10/27/88-08:29, TDS = 714
G -- 06/06/89-13:40, TDS = 728
H -- 10/25/89-13:25, TDS = 706
I -- 04/11/90-08:40, TDS = 650
J -- 06/05/91-12:15, TDS = 778
K -- 09/11/92-13:41, TDS = 732
L -- 08/27/93-14:30, TDS = 716
M -- 08/02/94-10:30, TDS = 770
N -- 07/21/95-13:50, TDS = 760
O -- 07/17/96-11:30, TDS = 770
P -- 07/17/97-10:15, TDS = 790
Q -- 09/09/98-11:13, TDS = 740
R -- 08/11/99-11:52, TDS = 760
S -- 07/25/00-08:36, TDS = 790
T -- 08/22/01-12:00, TDS = 750
U -- 10/14/02-10:20, TDS = 870
V -- 08/11/03-12:05, TDS = 750
W -- 02/18/04-12:50, TDS = 790
X -- 08/04/04-09:32, TDS = 930
Y -- 03/02/05-13:52, TDS = 1000
Z -- 08/19/05-10:40, TDS = 1130
a -- 02/08/06-14:10, TDS = 920
b -- 08/10/06-10:10, TDS = 2310
c -- 12/04/06-13:07, TDS = 1780
d -- 03/14/07-10:55, TDS = 1550
e -- 07/11/07-10:26, TDS = 1950
f -- 03/26/08-11:40, TDS = 1450
g -- 07/14/08-13:13, TDS = 1980
h -- 03/31/09-11:14, TDS = 1970
i -- 07/17/09-14:54, TDS = 2250
j -- 05/04/10-10:43, TDS = 1750
k -- 12/09/10-16:35, TDS = 1820
l -- 06/13/11-16:06, TDS = 1710
m -- 05/29/12-12:52, TDS = 1640
n -- 10/25/12-12:52, TDS = 1590
o -- 06/06/13-11:56, TDS = 1630
p -- 06/24/14-12:20, TDS = 1580
q -- 05/22/15-14:35, TDS = 1590
r -- 04/28/16-12:07, TDS = 1600
s -- 05/08/17-12:20, TDS = 1810
t -- 05/14/18-10:20, TDS = 1600



Percent Of Total Milliequivalents Per Liter

WEPO43

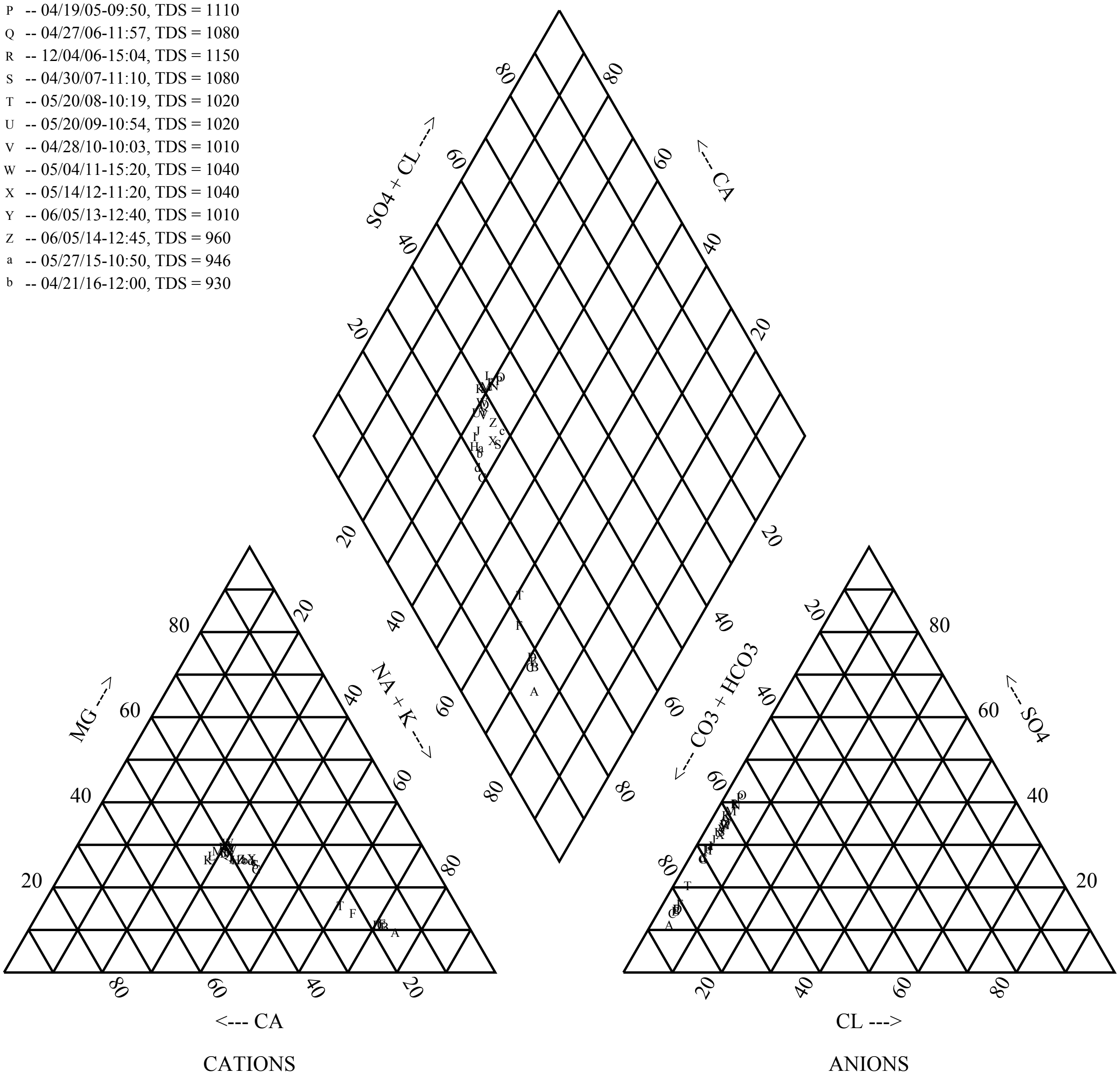
A -- 06/17/86-12:48, TDS = 910
B -- 11/18/86-09:40, TDS = 1724
C -- 04/03/87-10:49, TDS = 1860
D -- 08/04/87-09:45, TDS = 1750
E -- 10/07/87-09:25, TDS = 1800
F -- 06/06/88-15:05, TDS = 1626
G -- 10/17/88-14:30, TDS = 1642
H -- 05/22/89-14:30, TDS = 1872
I -- 11/08/89-11:45, TDS = 1658
J -- 04/11/90-14:05, TDS = 1076
K -- 05/14/91-11:40, TDS = 672
L -- 08/30/92-10:00, TDS = 750
M -- 08/26/93-10:20, TDS = 1700
N -- 08/03/94-13:53, TDS = 1582
O -- 05/19/95-13:00, TDS = 1180
P -- 08/24/95-09:26, TDS = 1020
Q -- 08/21/96-12:20, TDS = 1210



Percent Of Total Milliequivalents Per Liter

WEPO43R

A -- 07/23/97-16:15, TDS = 1060
B -- 11/04/97-15:15, TDS = 990
C -- 03/04/98-14:50, TDS = 1030
D -- 06/03/98-11:28, TDS = 1010
E -- 08/28/98-14:50, TDS = 1080
F -- 11/02/98-13:44, TDS = 1000
G -- 03/10/99-15:29, TDS = 940
H -- 05/21/99-10:52, TDS = 950
I -- 08/23/99-10:04, TDS = 970
J -- 10/21/99-11:08, TDS = 950
K -- 09/21/00-11:00, TDS = 1030
L -- 02/19/01-13:00, TDS = 1080
M -- 05/13/02-09:15, TDS = 1090
N -- 05/05/03-11:00, TDS = 1110
O -- 05/13/04-09:13, TDS = 1150
P -- 04/19/05-09:50, TDS = 1110
Q -- 04/27/06-11:57, TDS = 1080
R -- 12/04/06-15:04, TDS = 1150
S -- 04/30/07-11:10, TDS = 1080
T -- 05/20/08-10:19, TDS = 1020
U -- 05/20/09-10:54, TDS = 1020
V -- 04/28/10-10:03, TDS = 1010
W -- 05/04/11-15:20, TDS = 1040
X -- 05/14/12-11:20, TDS = 1040
Y -- 06/05/13-12:40, TDS = 1010
Z -- 06/05/14-12:45, TDS = 960
a -- 05/27/15-10:50, TDS = 946
b -- 04/21/16-12:00, TDS = 930
c -- 05/01/17-11:15, TDS = 934
d -- 04/26/18-12:05, TDS = 924

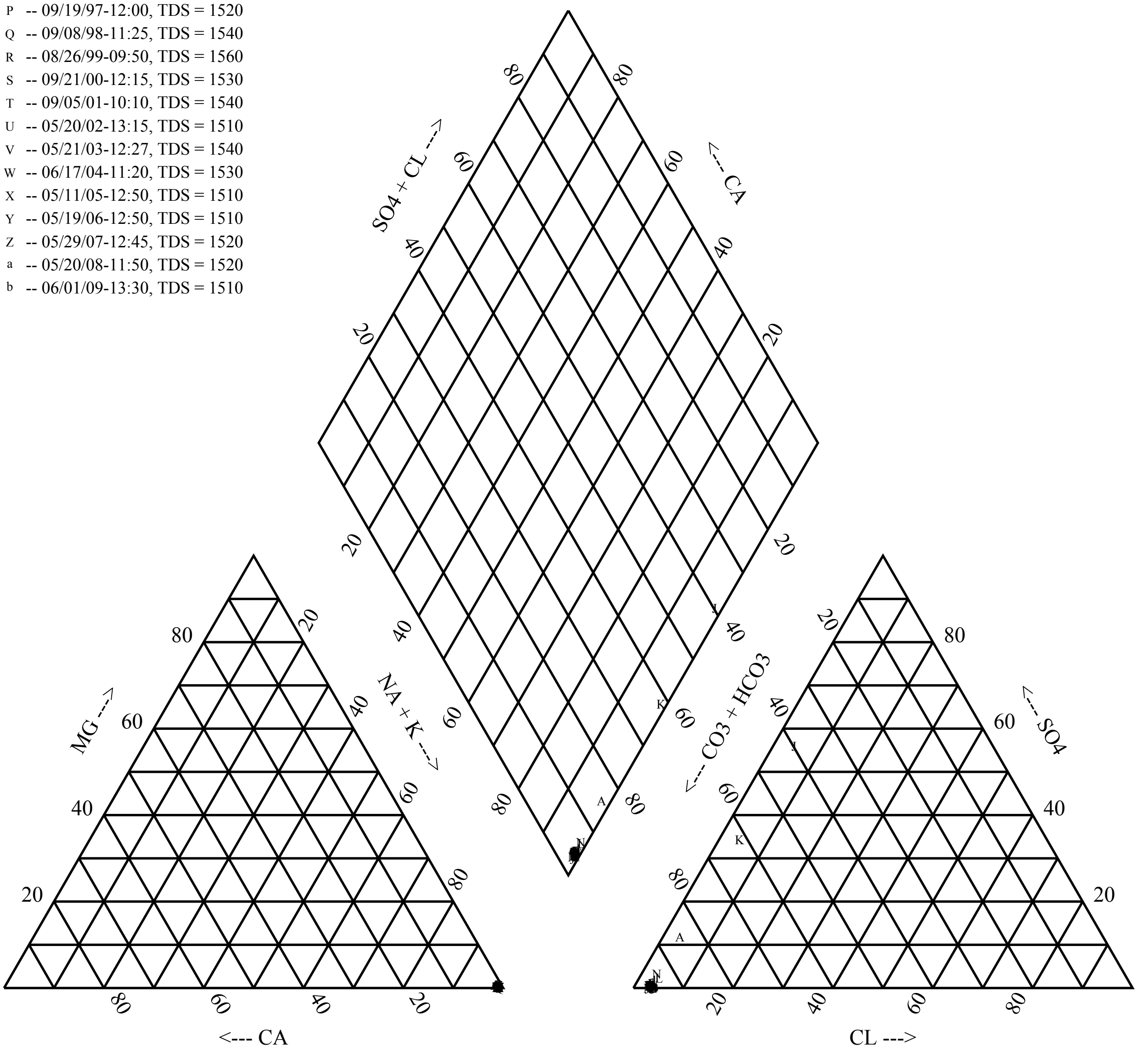


Percent Of Total Milliequivalents Per Liter

WEPO44

A -- 06/13/86-12:30, TDS = 1900
B -- 11/18/86-10:22, TDS = 1662
C -- 08/04/87-11:25, TDS = 1622
D -- 10/08/87-13:17, TDS = 1638
E -- 06/06/88-15:31, TDS = 1688
F -- 10/17/88-13:51, TDS = 1702
G -- 06/12/89-09:00, TDS = 1638
H -- 11/28/89-08:00, TDS = 1664
I -- 04/11/90-13:15, TDS = 1618
J -- 05/14/91-10:20, TDS = 2615
K -- 09/15/92-09:42, TDS = 1624
L -- 09/14/93-11:15, TDS = 1570
M -- 08/16/94-10:32, TDS = 1602
N -- 09/05/95-12:25, TDS = 1550
O -- 08/28/96-11:30, TDS = 1550
P -- 09/19/97-12:00, TDS = 1520
Q -- 09/08/98-11:25, TDS = 1540
R -- 08/26/99-09:50, TDS = 1560
S -- 09/21/00-12:15, TDS = 1530
T -- 09/05/01-10:10, TDS = 1540
U -- 05/20/02-13:15, TDS = 1510
V -- 05/21/03-12:27, TDS = 1540
W -- 06/17/04-11:20, TDS = 1530
X -- 05/11/05-12:50, TDS = 1510
Y -- 05/19/06-12:50, TDS = 1510
Z -- 05/29/07-12:45, TDS = 1520
a -- 05/20/08-11:50, TDS = 1520
b -- 06/01/09-13:30, TDS = 1510

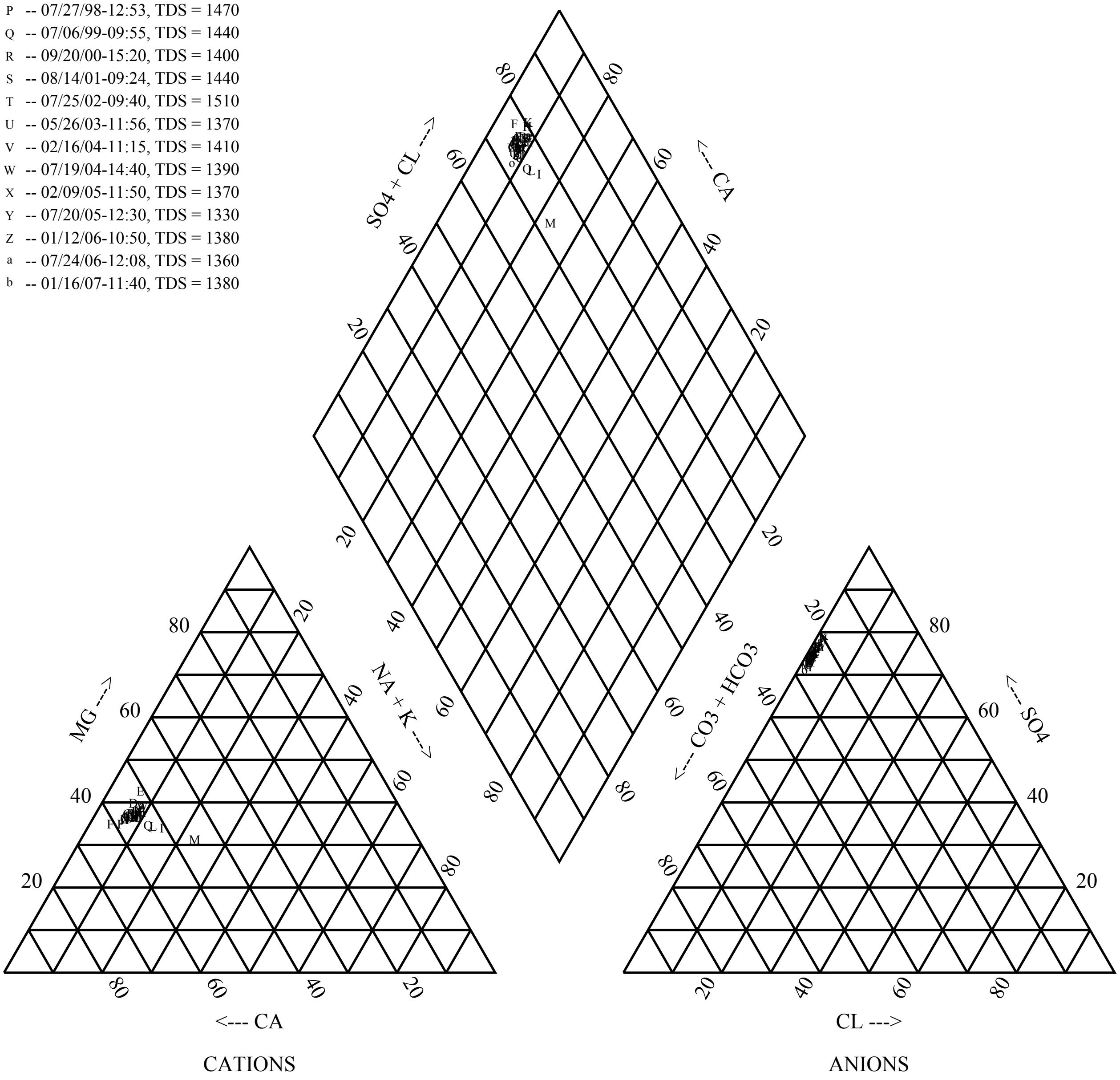
c -- 05/04/10-12:50, TDS = 1500
d -- 05/13/11-13:20, TDS = 1510
e -- 05/14/12-12:41, TDS = 1520
f -- 06/05/13-13:33, TDS = 1460
g -- 06/24/14-11:30, TDS = 1420
h -- 05/27/15-11:26, TDS = 1490
i -- 04/21/16-11:30, TDS = 1490
j -- 05/01/17-10:50, TDS = 1480
k -- 04/26/18-12:38, TDS = 1490



Percent Of Total Milliequivalents Per Liter

WEPO49

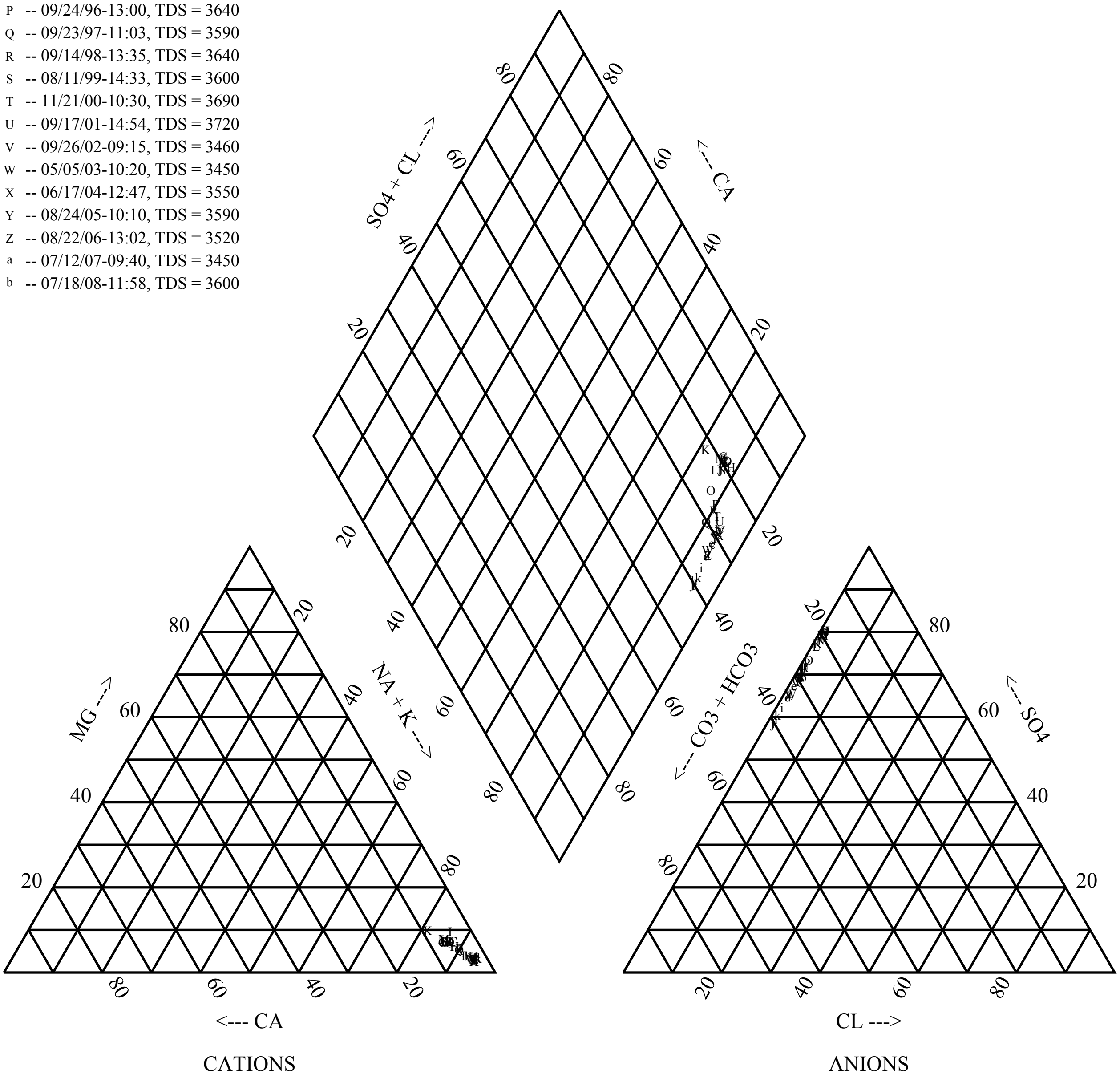
A -- 06/17/86-12:00, TDS = 1415
B -- 08/18/87-11:52, TDS = 1360
C -- 10/22/87-14:50, TDS = 1400
D -- 06/06/88-10:47, TDS = 1408
E -- 10/19/88-09:51, TDS = 1404
F -- 06/06/89-16:30, TDS = 1408
G -- 10/26/89-09:55, TDS = 1404
H -- 05/10/90-09:50, TDS = 1390
I -- 06/10/91-13:10, TDS = 1368
J -- 08/27/92-11:19, TDS = 1340
K -- 09/15/93-12:48, TDS = 1382
L -- 09/20/94-14:29, TDS = 1290
M -- 07/27/95-10:05, TDS = 1300
N -- 08/22/96-14:30, TDS = 1380
O -- 09/16/97-14:10, TDS = 1370
P -- 07/27/98-12:53, TDS = 1470
Q -- 07/06/99-09:55, TDS = 1440
R -- 09/20/00-15:20, TDS = 1400
S -- 08/14/01-09:24, TDS = 1440
T -- 07/25/02-09:40, TDS = 1510
U -- 05/26/03-11:56, TDS = 1370
V -- 02/16/04-11:15, TDS = 1410
W -- 07/19/04-14:40, TDS = 1390
X -- 02/09/05-11:50, TDS = 1370
Y -- 07/20/05-12:30, TDS = 1330
Z -- 01/12/06-10:50, TDS = 1380
a -- 07/24/06-12:08, TDS = 1360
b -- 01/16/07-11:40, TDS = 1380
c -- 07/06/07-13:28, TDS = 1420
d -- 02/27/08-10:28, TDS = 1360
e -- 07/07/08-14:25, TDS = 1360
f -- 02/04/09-14:50, TDS = 1380
g -- 04/30/10-10:38, TDS = 1380
h -- 02/28/11-16:25, TDS = 1370
i -- 04/09/12-11:32, TDS = 1380
j -- 05/02/13-12:00, TDS = 1390
k -- 05/12/14-11:30, TDS = 1410
l -- 04/10/15-14:50, TDS = 1410
m -- 04/26/16-14:20, TDS = 1390
n -- 05/03/17-11:30, TDS = 1390
o -- 04/23/18-10:20, TDS = 1450



Percent Of Total Milliequivalents Per Liter

WEPO53

A -- 06/13/86-10:55, TDS = 4400
B -- 10/24/86-12:55, TDS = 4324
C -- 04/03/87-09:32, TDS = 4256
D -- 08/18/87-14:35, TDS = 4296
E -- 10/08/87-15:05, TDS = 4218
F -- 04/27/88-11:37, TDS = 4380
G -- 10/19/88-08:40, TDS = 4368
H -- 06/06/89-14:40, TDS = 4380
I -- 11/29/89-10:30, TDS = 4324
J -- 04/11/90-12:10, TDS = 4144
K -- 05/29/91-13:30, TDS = 3840
L -- 08/24/92-14:06, TDS = 4240
M -- 09/15/93-09:35, TDS = 4214
N -- 09/07/94-11:08, TDS = 4040
O -- 09/04/95-12:20, TDS = 4010
P -- 09/24/96-13:00, TDS = 3640
Q -- 09/23/97-11:03, TDS = 3590
R -- 09/14/98-13:35, TDS = 3640
S -- 08/11/99-14:33, TDS = 3600
T -- 11/21/00-10:30, TDS = 3690
U -- 09/17/01-14:54, TDS = 3720
V -- 09/26/02-09:15, TDS = 3460
W -- 05/05/03-10:20, TDS = 3450
X -- 06/17/04-12:47, TDS = 3550
Y -- 08/24/05-10:10, TDS = 3590
Z -- 08/22/06-13:02, TDS = 3520
a -- 07/12/07-09:40, TDS = 3450
b -- 07/18/08-11:58, TDS = 3600
c -- 09/11/09-11:03, TDS = 3600
d -- 09/16/10-15:25, TDS = 3310
e -- 07/21/11-13:00, TDS = 3400
f -- 10/16/12-12:26, TDS = 3500
g -- 07/10/13-11:14, TDS = 3570
h -- 10/24/14-12:57, TDS = 2950
i -- 10/19/15-10:46, TDS = 3060
j -- 07/15/16-13:48, TDS = 3010
k -- 08/16/17-15:05, TDS = 2950
l -- 07/24/18-09:50, TDS = 3000

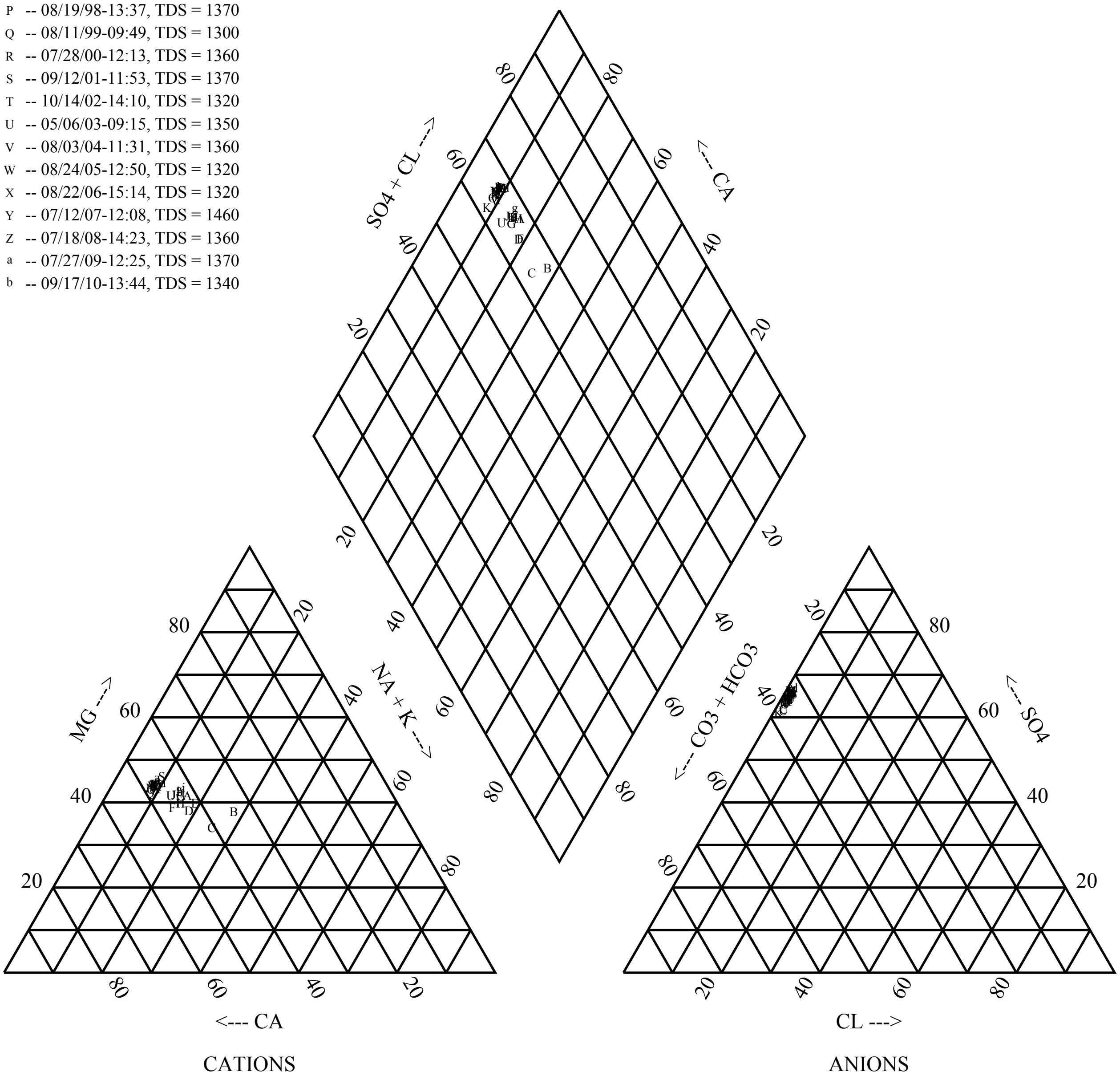


Percent Of Total Milliequivalents Per Liter

WEPO54

A -- 06/17/86-11:20, TDS = 1405
B -- 08/18/87-13:33, TDS = 1468
C -- 10/22/87-12:40, TDS = 1490
D -- 06/06/88-11:17, TDS = 1456
E -- 10/19/88-09:19, TDS = 1392
F -- 06/08/89-10:20, TDS = 1340
G -- 10/26/89-09:00, TDS = 1338
H -- 05/10/90-09:00, TDS = 1352
I -- 06/05/91-09:50, TDS = 1362
J -- 08/27/92-10:11, TDS = 1262
K -- 09/15/93-11:15, TDS = 1258
L -- 09/07/94-14:38, TDS = 1262
M -- 07/27/95-13:04, TDS = 1310
N -- 07/25/96-15:15, TDS = 1300
O -- 09/16/97-11:15, TDS = 1270
P -- 08/19/98-13:37, TDS = 1370
Q -- 08/11/99-09:49, TDS = 1300
R -- 07/28/00-12:13, TDS = 1360
S -- 09/12/01-11:53, TDS = 1370
T -- 10/14/02-14:10, TDS = 1320
U -- 05/06/03-09:15, TDS = 1350
V -- 08/03/04-11:31, TDS = 1360
W -- 08/24/05-12:50, TDS = 1320
X -- 08/22/06-15:14, TDS = 1320
Y -- 07/12/07-12:08, TDS = 1460
Z -- 07/18/08-14:23, TDS = 1360
a -- 07/27/09-12:25, TDS = 1370
b -- 09/17/10-13:44, TDS = 1340

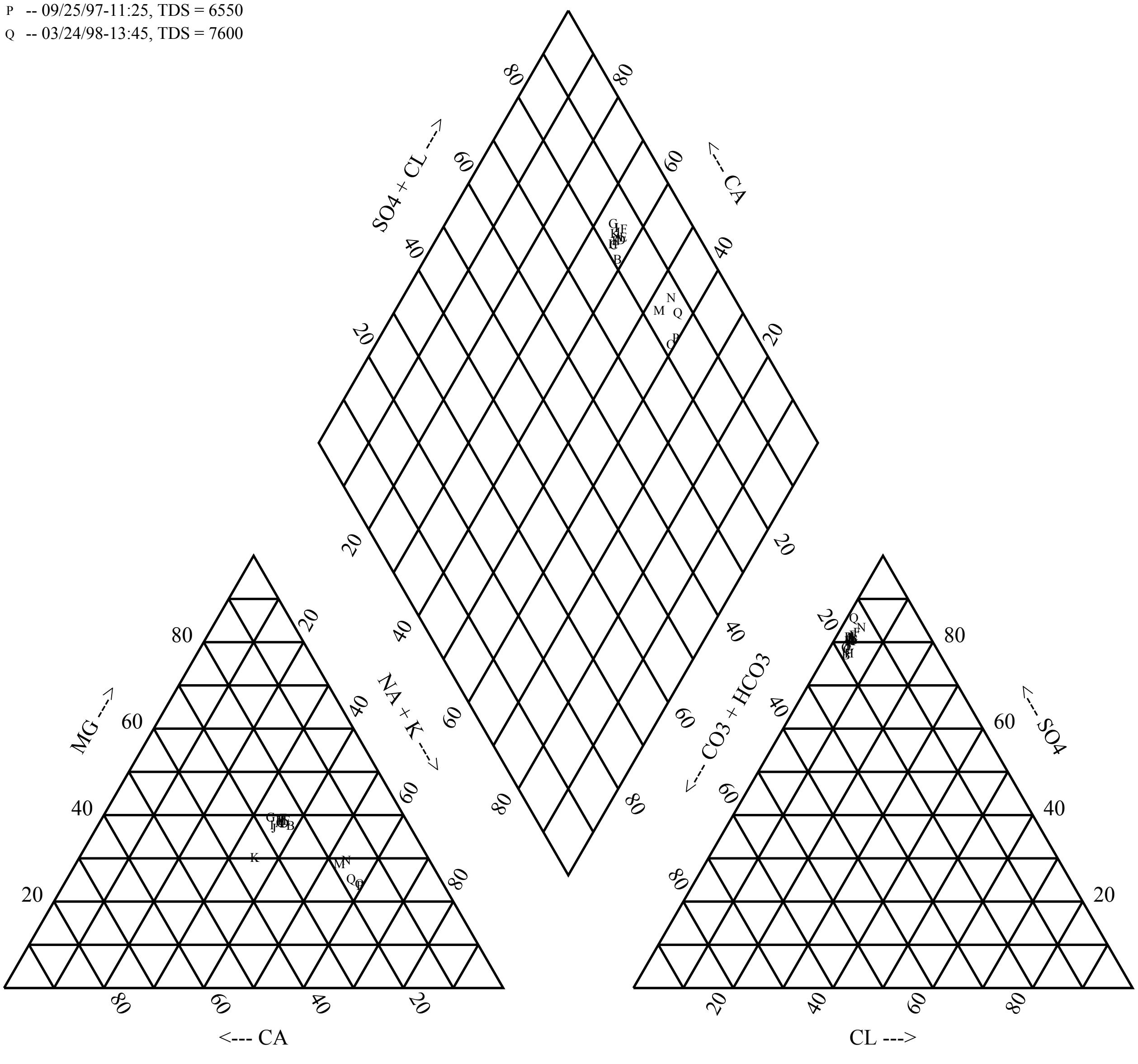
c -- 07/19/11-14:15, TDS = 1430
d -- 07/20/12-10:45, TDS = 1430
e -- 07/10/13-13:10, TDS = 1430
f -- 08/04/14-14:27, TDS = 1370
g -- 09/09/15-12:24, TDS = 1410
h -- 07/15/16-14:38, TDS = 1440
i -- 08/10/17-13:40, TDS = 1340
j -- 07/24/18-10:23, TDS = 1440



Percent Of Total Milliequivalents Per Liter

WEPO62

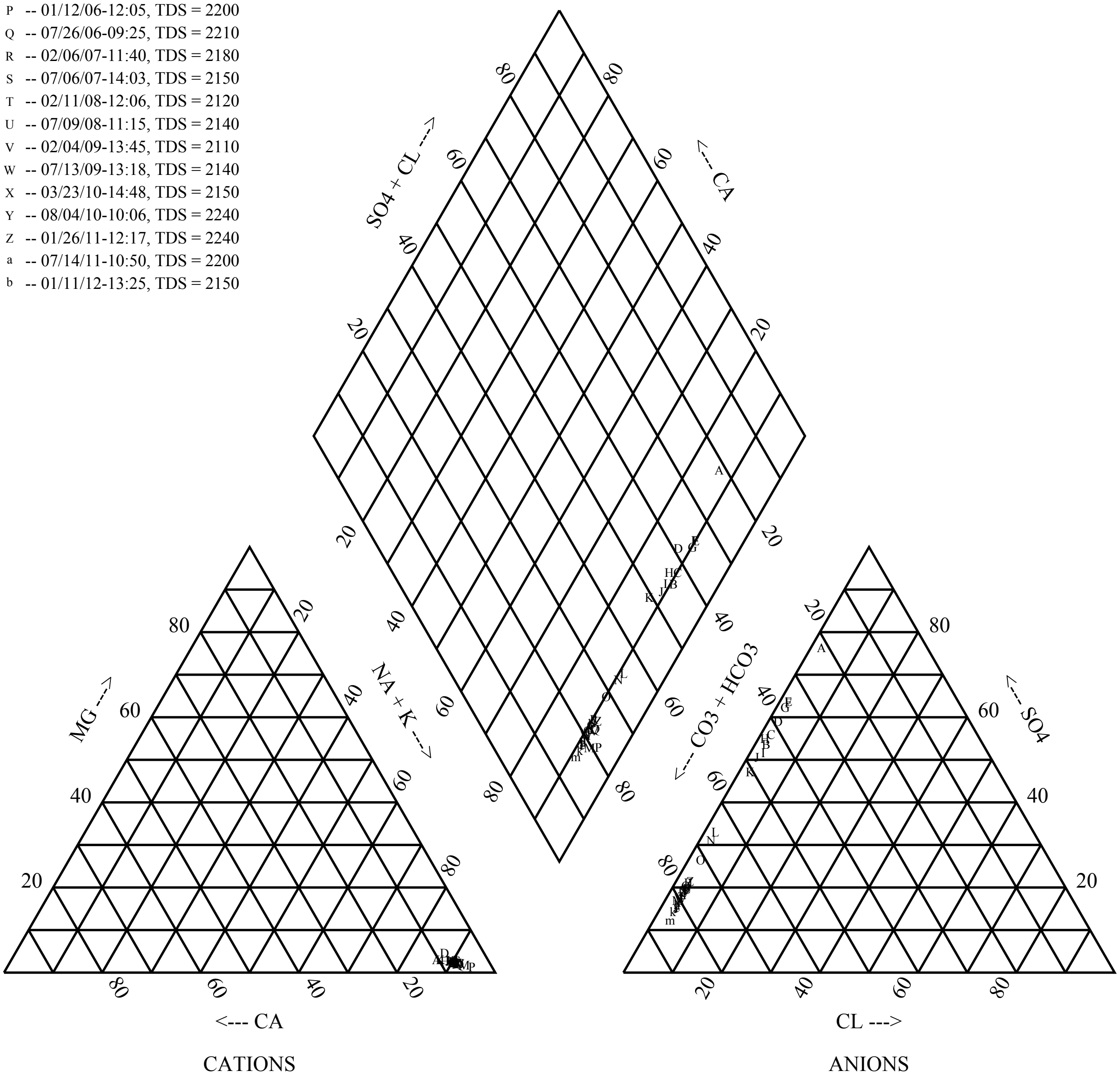
A -- 06/17/86-10:35, TDS = 6375
B -- 08/18/87-11:00, TDS = 6180
C -- 10/22/87-11:00, TDS = 6304
D -- 06/02/88-10:52, TDS = 6474
E -- 10/19/88-10:51, TDS = 6418
F -- 06/08/89-09:15, TDS = 6466
G -- 11/28/89-13:23, TDS = 5332
H -- 05/10/90-12:45, TDS = 6664
I -- 06/10/91-12:00, TDS = 5912
J -- 08/27/92-12:26, TDS = 5314
K -- 09/01/93-15:25, TDS = 3846
L -- 09/20/94-11:43, TDS = 5634
M -- 08/21/95-13:40, TDS = 6220
N -- 10/02/96-15:30, TDS = 5790
O -- 03/26/97-13:50, TDS = 5730
P -- 09/25/97-11:25, TDS = 6550
Q -- 03/24/98-13:45, TDS = 7600



Percent Of Total Milliequivalents Per Liter

WEPO62R

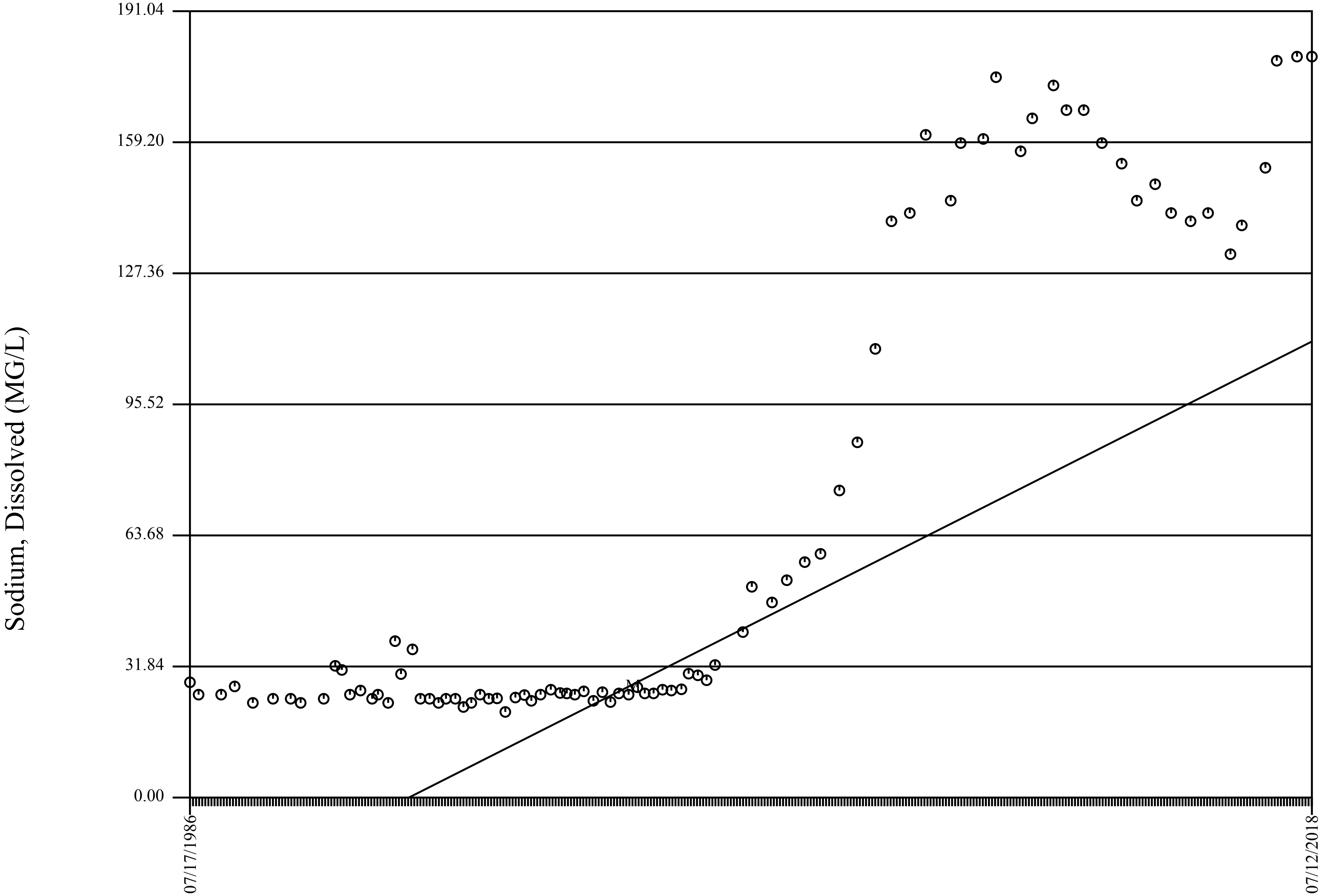
A -- 09/22/97-14:33, TDS = 1330
B -- 03/18/98-14:05, TDS = 1910
C -- 06/02/98-11:17, TDS = 1960
D -- 09/24/98-13:30, TDS = 2040
E -- 03/25/99-11:45, TDS = 1810
F -- 05/27/99-11:00, TDS = 1860
G -- 08/20/99-13:15, TDS = 1910
H -- 09/26/00-09:50, TDS = 2390
I -- 09/26/01-09:30, TDS = 2660
J -- 09/25/02-09:30, TDS = 2720
K -- 05/06/03-12:20, TDS = 2840
L -- 02/16/04-10:33, TDS = 2630
M -- 08/03/04-08:46, TDS = 2330
N -- 02/09/05-11:12, TDS = 2410
O -- 07/21/05-08:52, TDS = 2330
P -- 01/12/06-12:05, TDS = 2200
Q -- 07/26/06-09:25, TDS = 2210
R -- 02/06/07-11:40, TDS = 2180
S -- 07/06/07-14:03, TDS = 2150
T -- 02/11/08-12:06, TDS = 2120
U -- 07/09/08-11:15, TDS = 2140
V -- 02/04/09-13:45, TDS = 2110
W -- 07/13/09-13:18, TDS = 2140
X -- 03/23/10-14:48, TDS = 2150
Y -- 08/04/10-10:06, TDS = 2240
Z -- 01/26/11-12:17, TDS = 2240
a -- 07/14/11-10:50, TDS = 2200
b -- 01/11/12-13:25, TDS = 2150
c -- 07/10/12-12:07, TDS = 2120
d -- 03/04/13-13:18, TDS = 2000
e -- 05/29/13-12:25, TDS = 1980
f -- 01/29/14-14:45, TDS = 1900
g -- 07/14/14-12:25, TDS = 1910
h -- 02/09/15-11:46, TDS = 1850
i -- 08/19/15-15:23, TDS = 1880
j -- 03/17/16-12:50, TDS = 1850
k -- 07/13/16-14:20, TDS = 1830
l -- 07/26/17-11:15, TDS = 1800
m -- 04/26/18-13:25, TDS = 1820



Percent Of Total Milliequivalents Per Liter

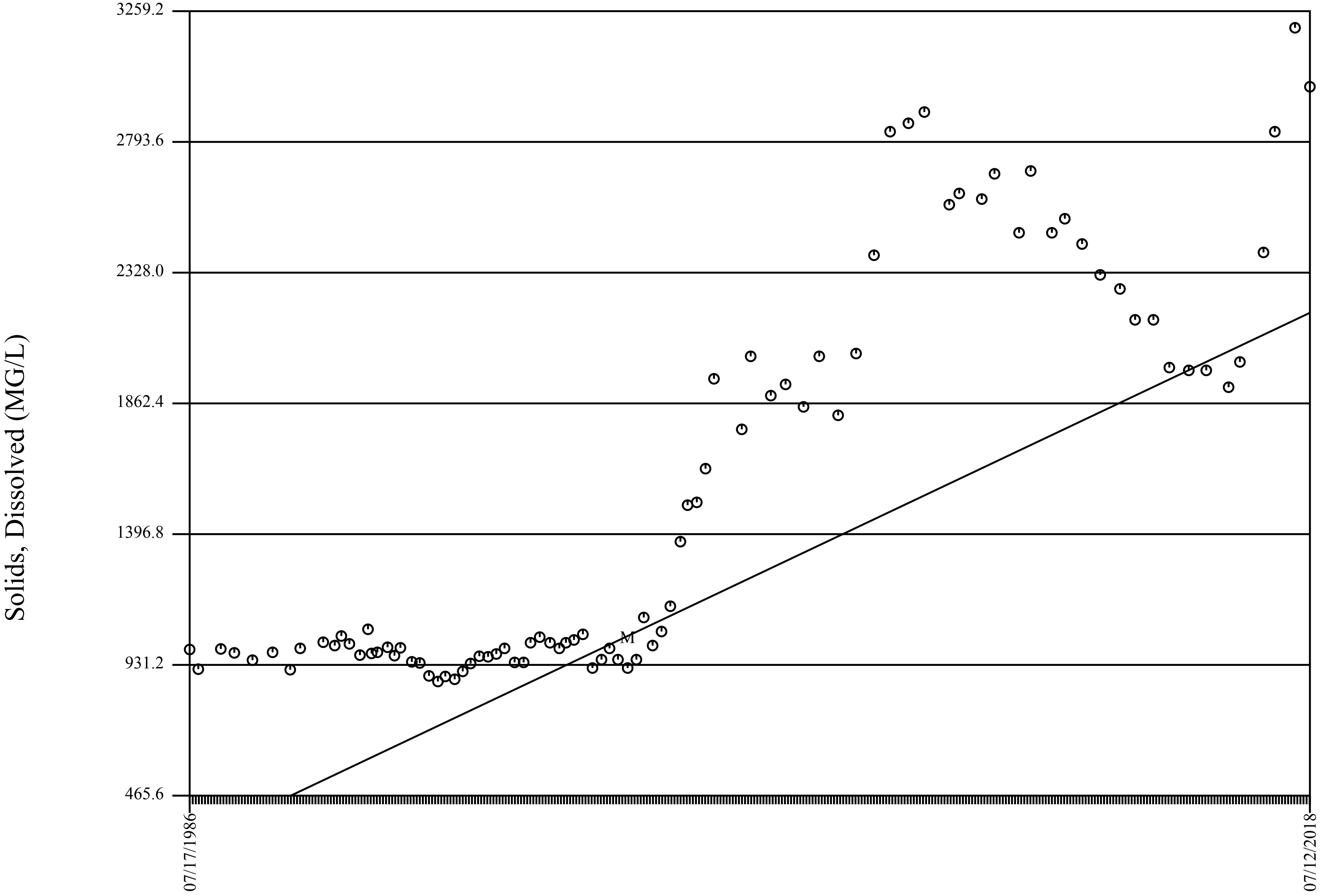
Attachment 3-4

Sen Estimate of Trend Slope Plots for Alluvial and Wepo Wells
Proximate to J-1/N-6, J-16 and N-14 TOJ Parcels



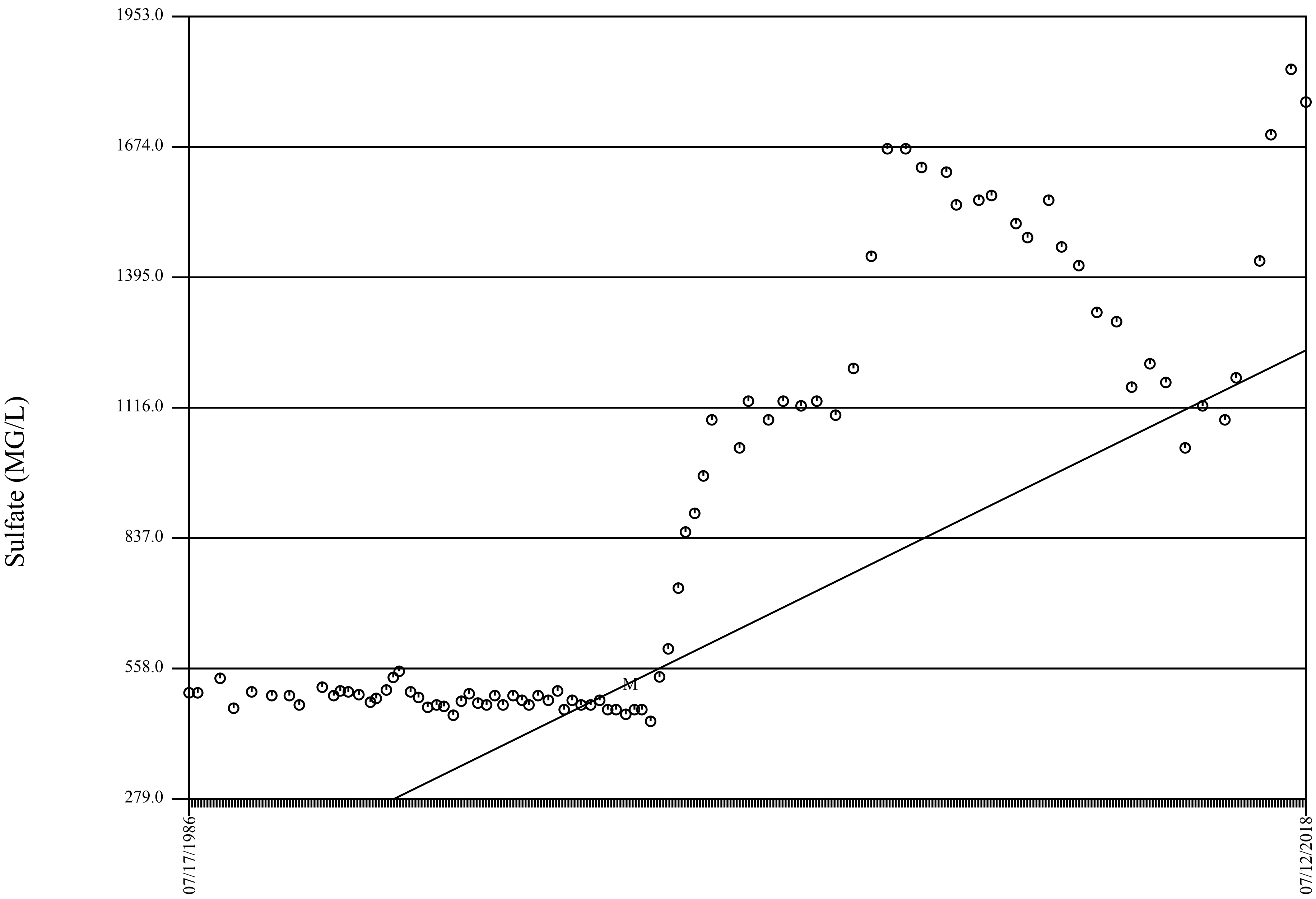
No censored data. 0.0118 Sen trend detected at 10.00% in 90.00% confidence interval 0.0075, 0.0146

ALUV17



No censored data. 0.1618 Sen trend detected at 10.00% in 90.00% confidence interval 0.1358, 0.1869

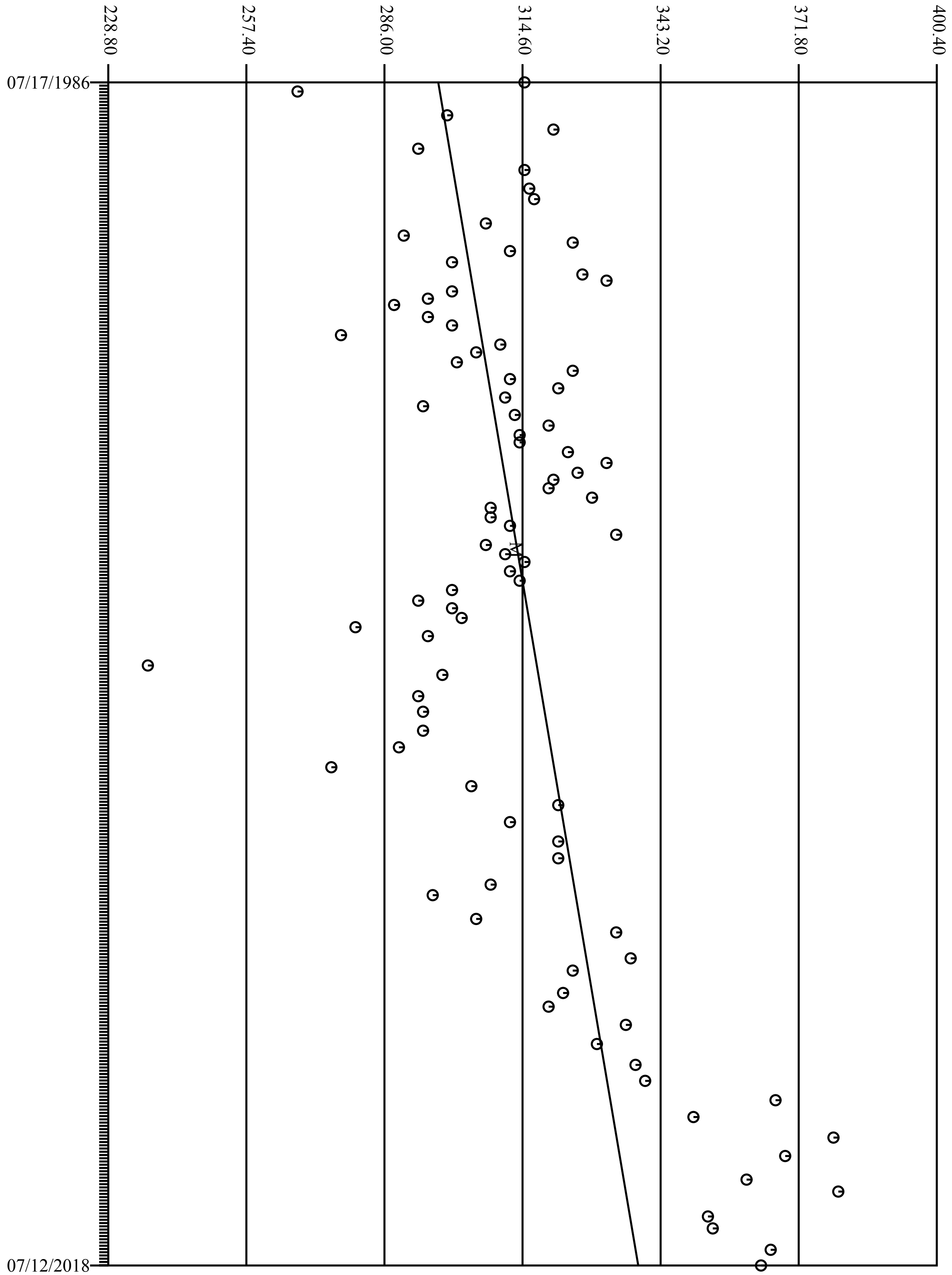
ALUV17



No censored data. 0.1006 Sen trend detected at 10.00% in 90.00% confidence interval 0.0803, 0.1189

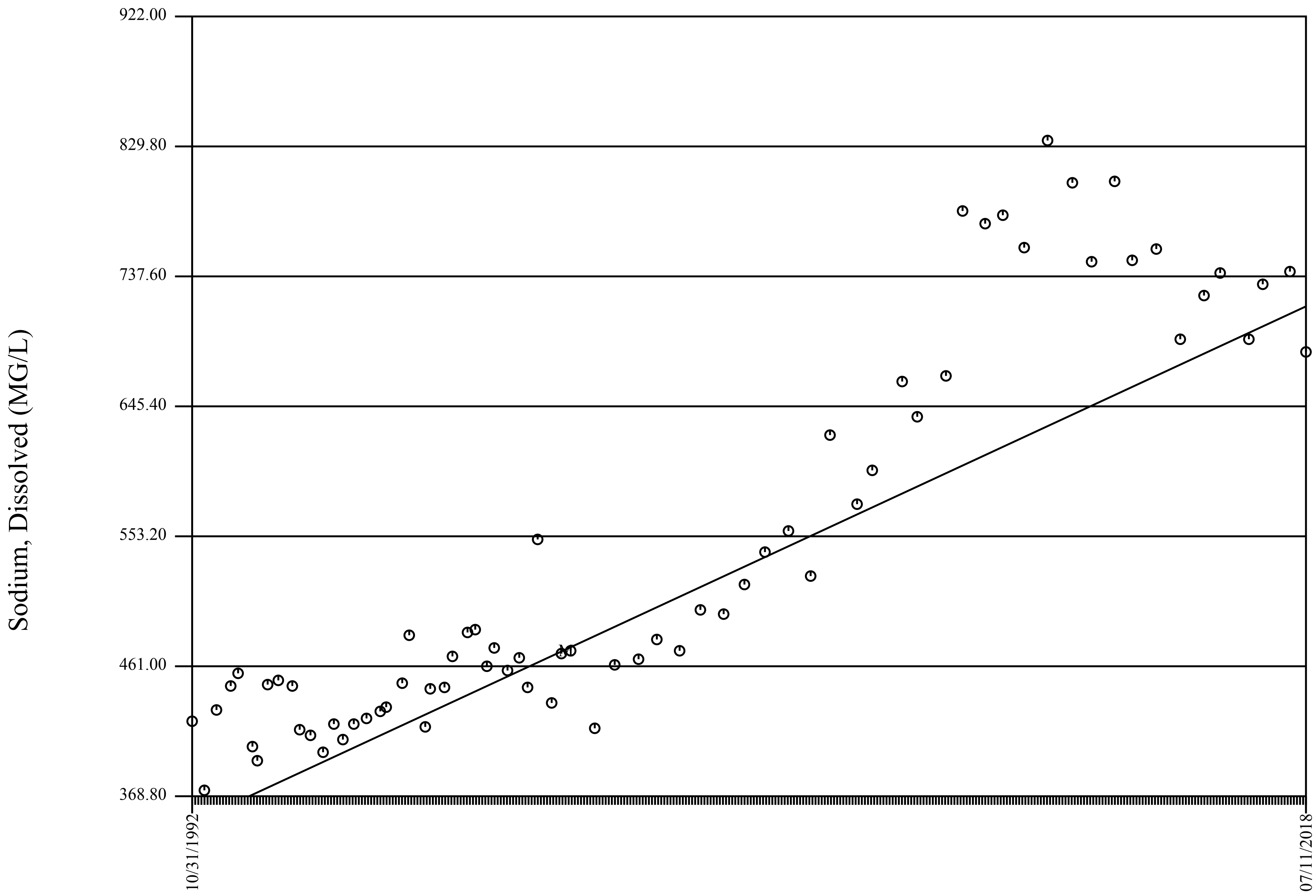
ALUV17

Bicarbonate As HCO3 (MG/L)



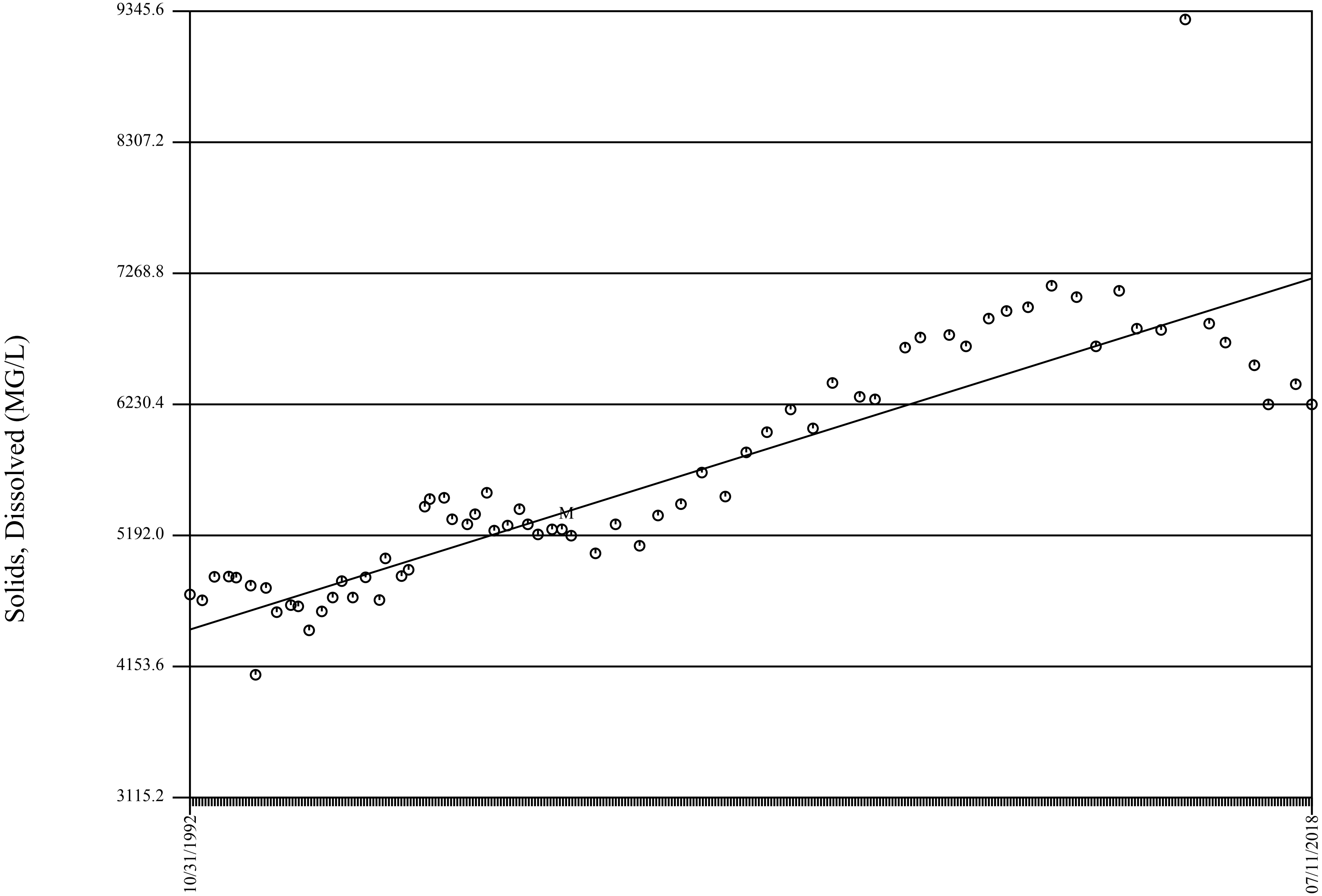
No censored data. 0.0035 Sen trend detected at 10.00% in 90.00% confidence interval 0.0023, 0.0047

ALUV17



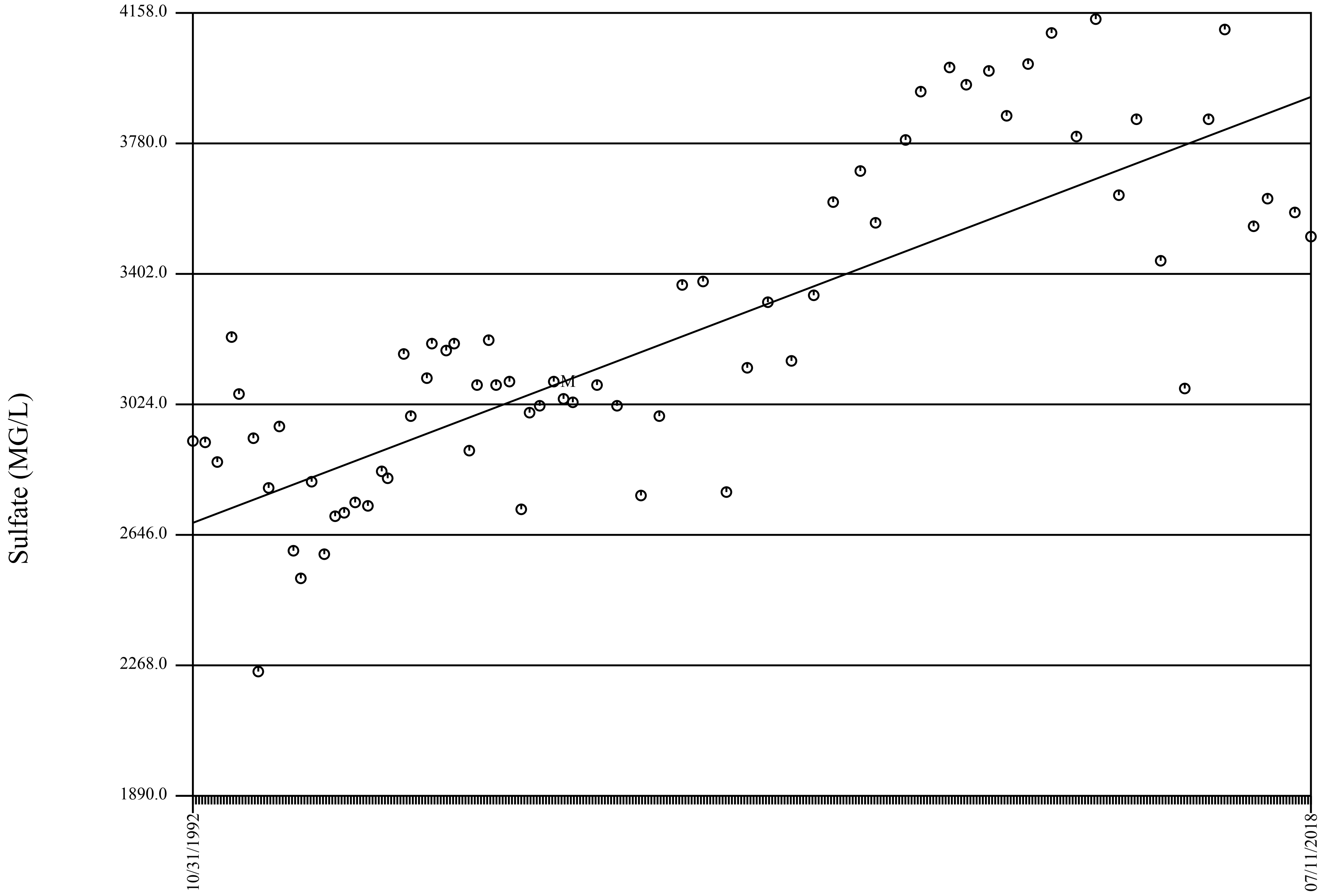
No censored data. 0.0390 Sen trend detected at 10.00% in 90.00% confidence interval 0.0347, 0.0430

ALUV193



No censored data. 0.2964 Sen trend detected at 10.00% in 90.00% confidence interval 0.2654, 0.3245

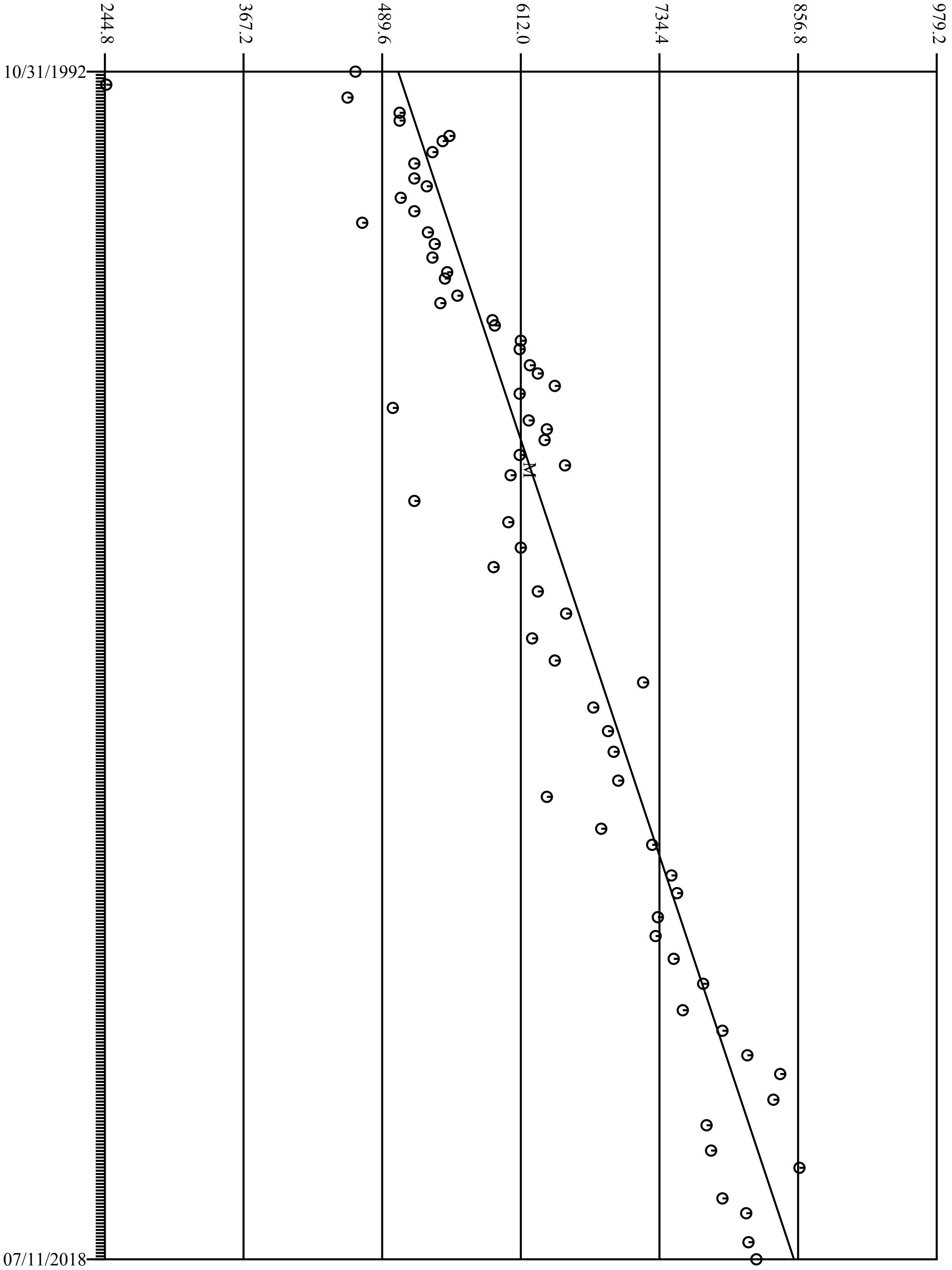
ALUV193



No censored data. 0.1315 Sen trend detected at 10.00% in 90.00% confidence interval 0.1069, 0.1564

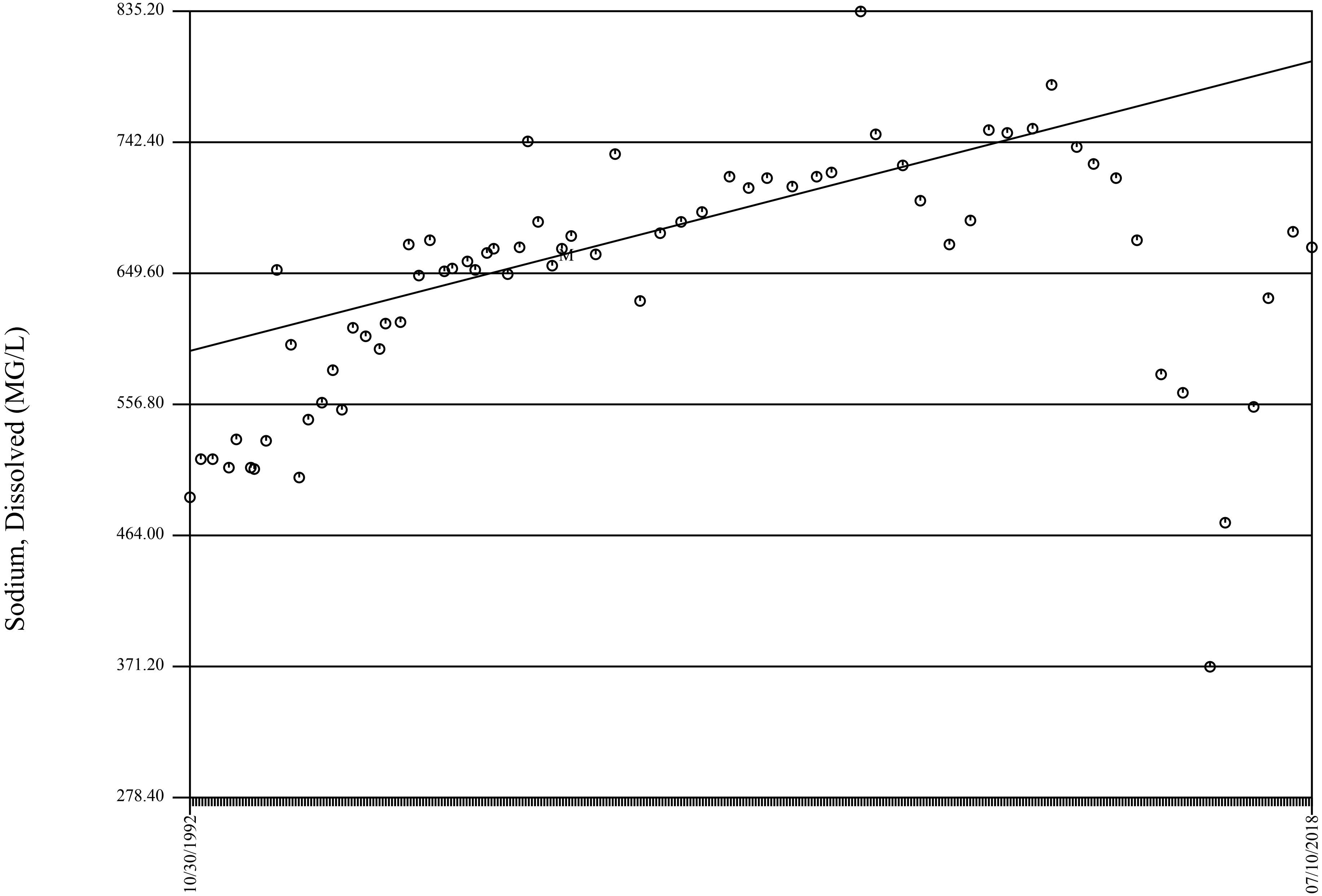
ALUV193

Bicarbonate As HCO3 (MG/L)



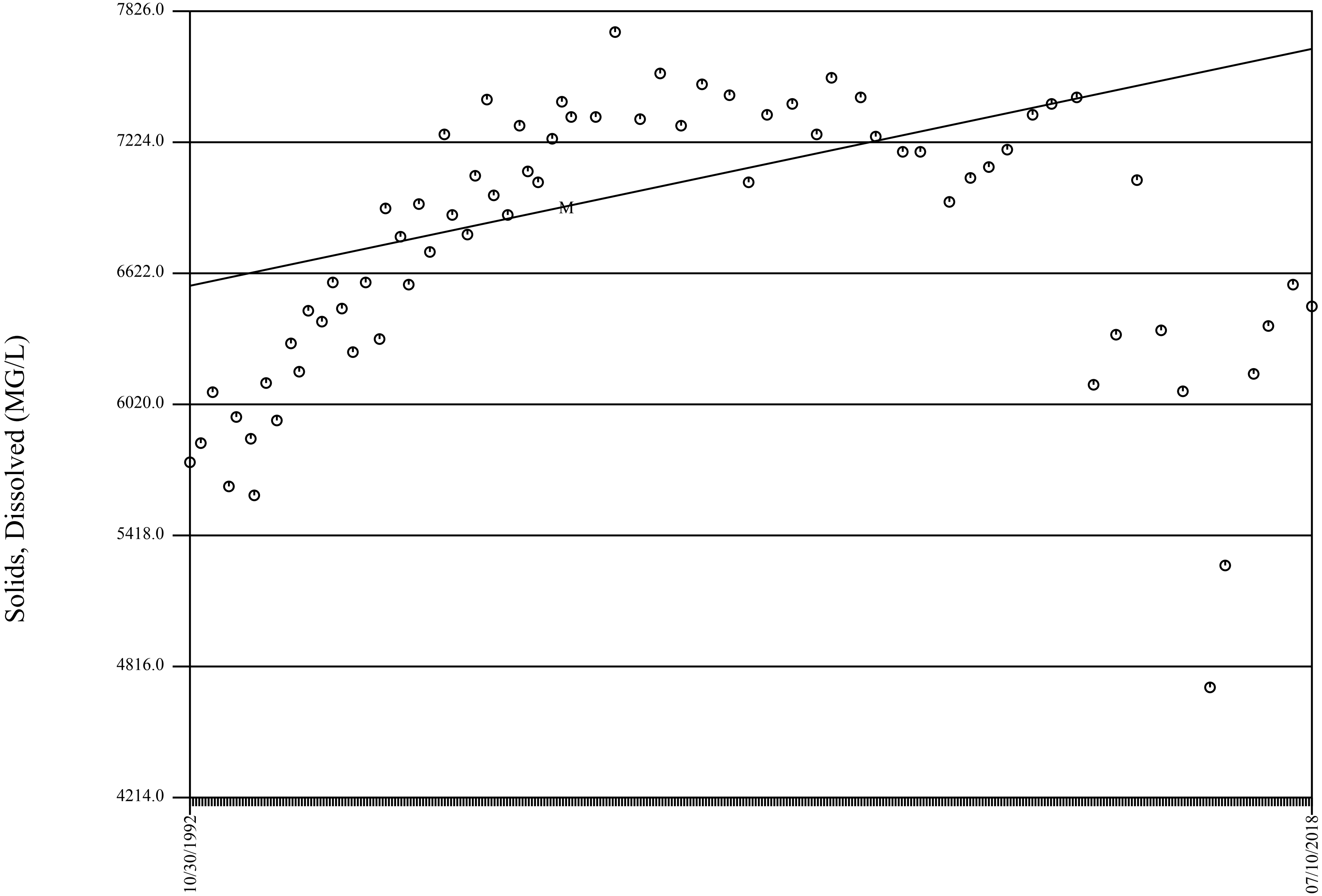
No censored data. 0.0372 Sen trend detected at 10.00% in 90.00% confidence interval 0.0350, 0.0400

ALUV193



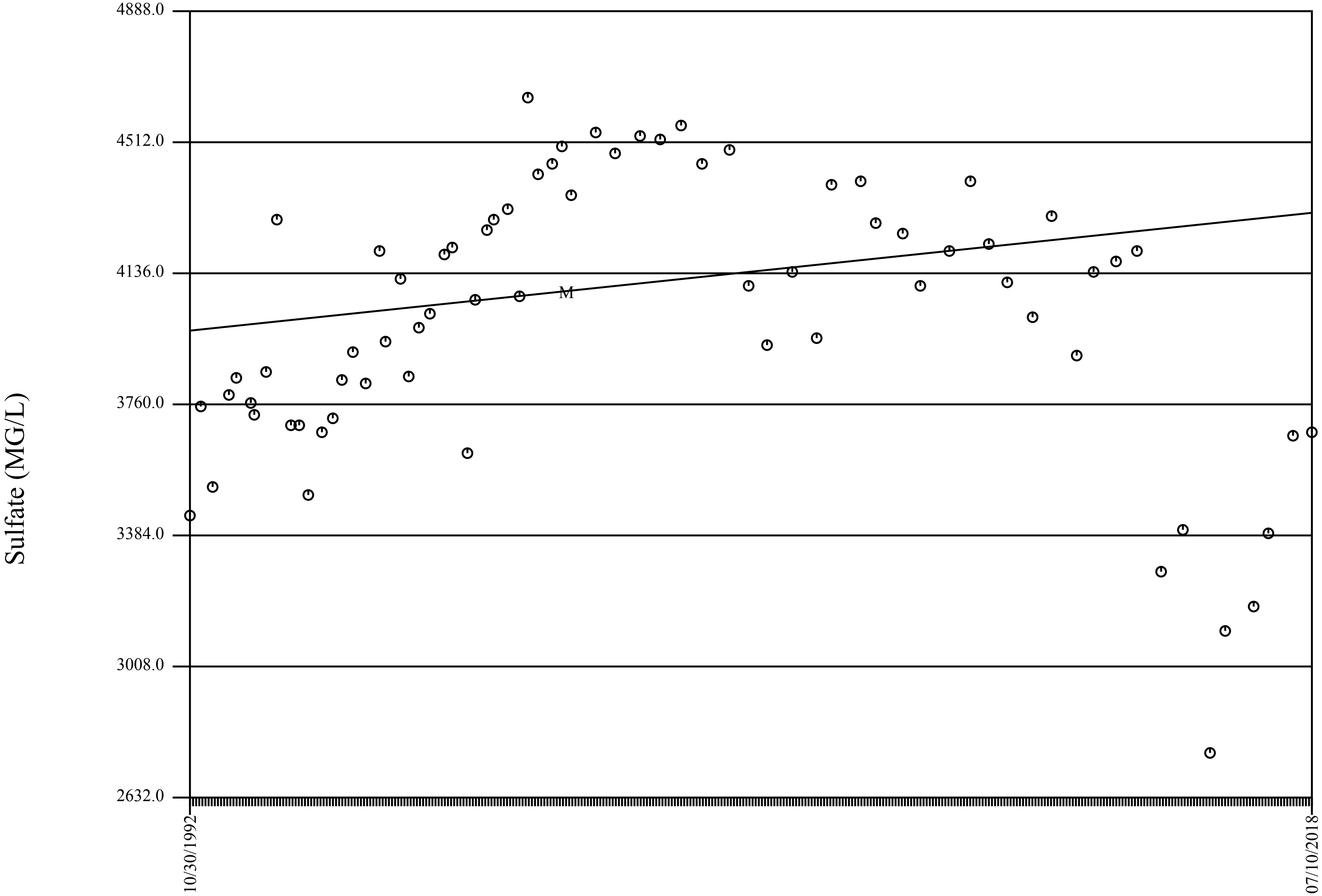
No censored data. 0.0219 Sen trend detected at 10.00% in 90.00% confidence interval 0.0167, 0.0270

ALUV197



No censored data. 0.1159 Sen trend detected at 10.00% in 90.00% confidence interval 0.0601, 0.1780

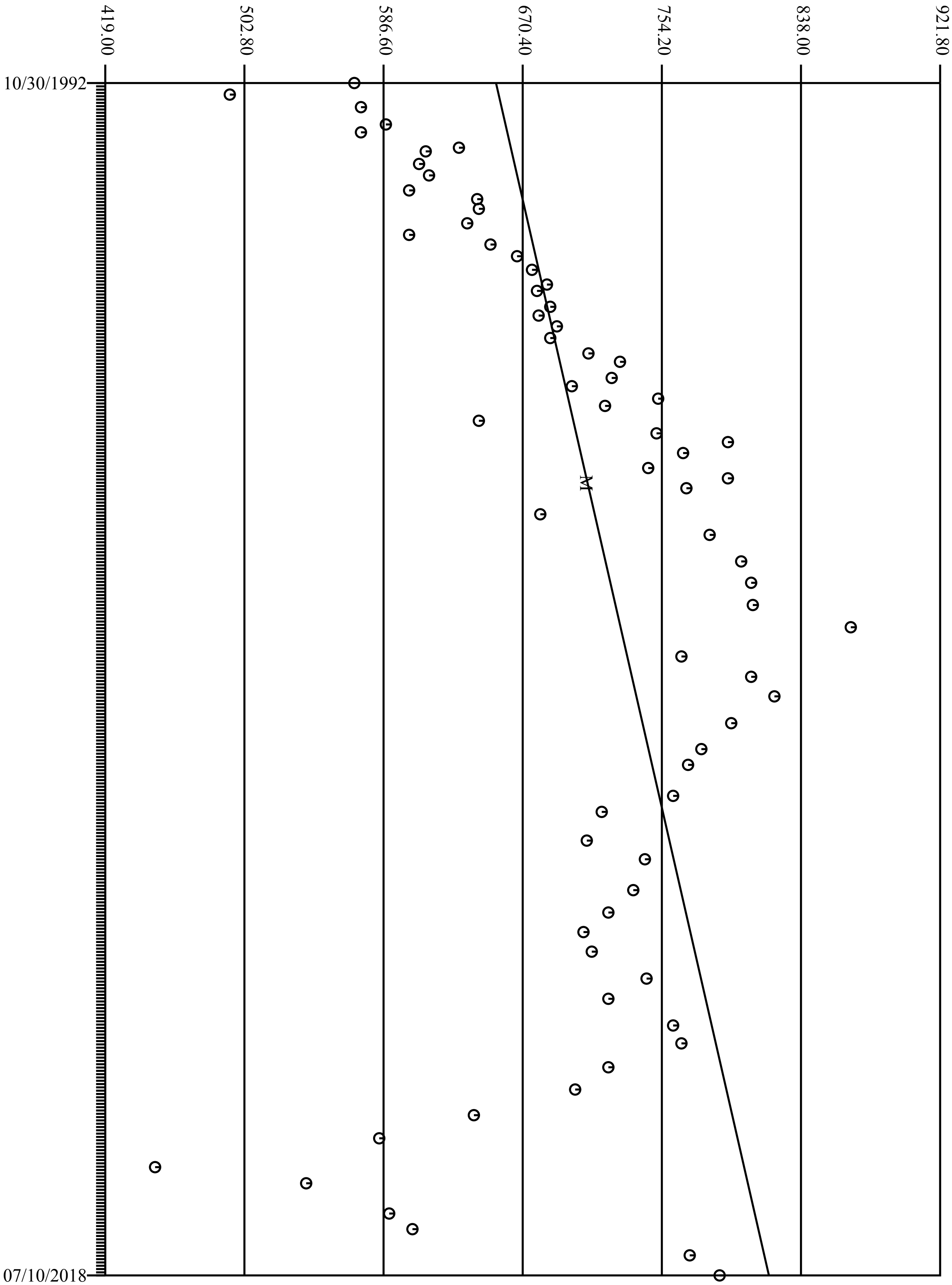
ALUV197



No censored data. 0.0360 Sen trend detected at 10.00% in 90.00% confidence interval -0.0042, 0.0671

ALUV197

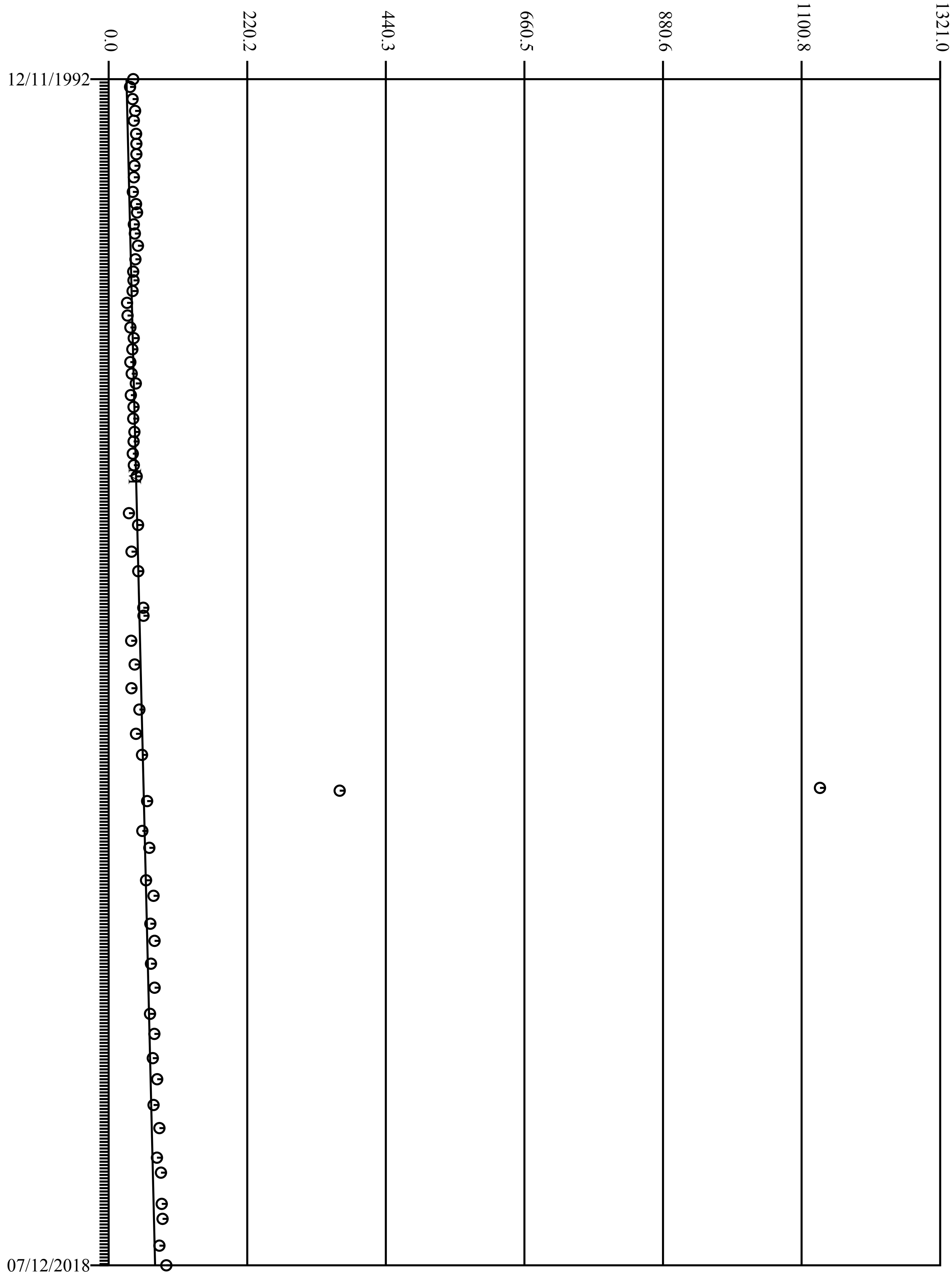
Bicarbonate As HCO3 (MG/L)



No censored data. 0.0175 Sen trend detected at 10.00% in 90.00% confidence interval 0.0116, 0.0241

ALUV197

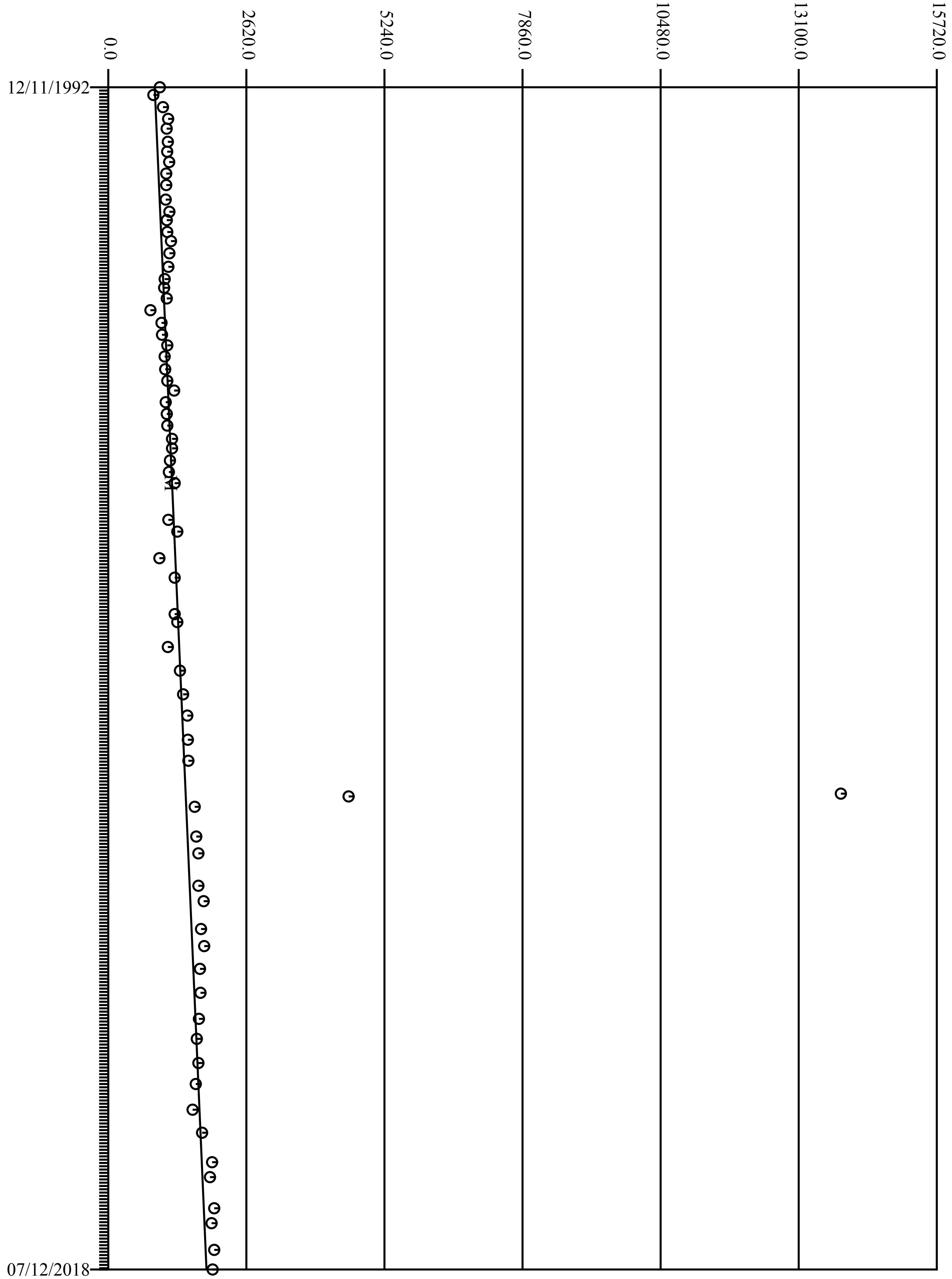
Sodium, Dissolved (MG/L)



No censored data. 0.0049 Sen trend detected at 10.00% in 90.00% confidence interval 0.0042, 0.0055

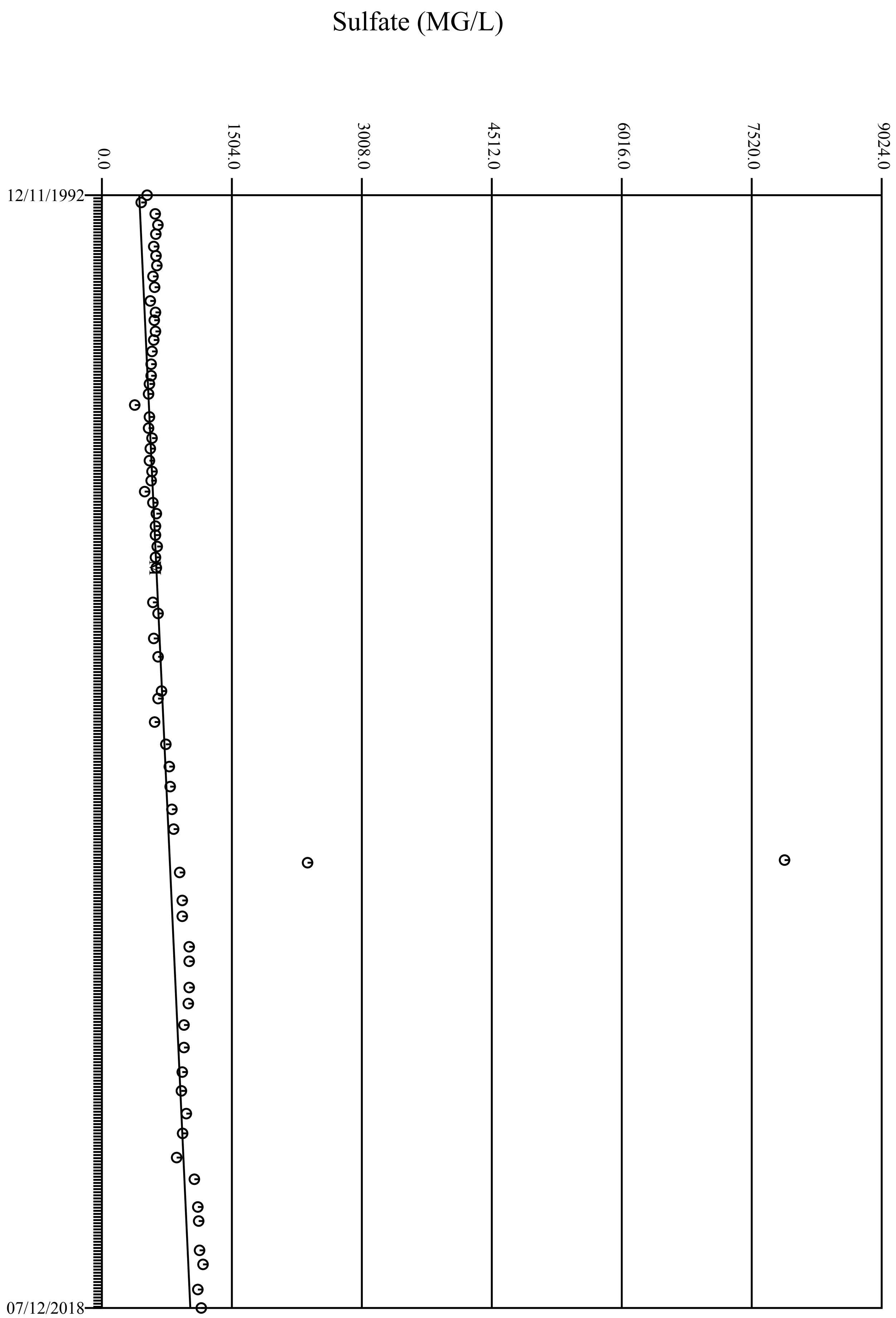
ALUV200

Solids, Dissolved (MG/L)



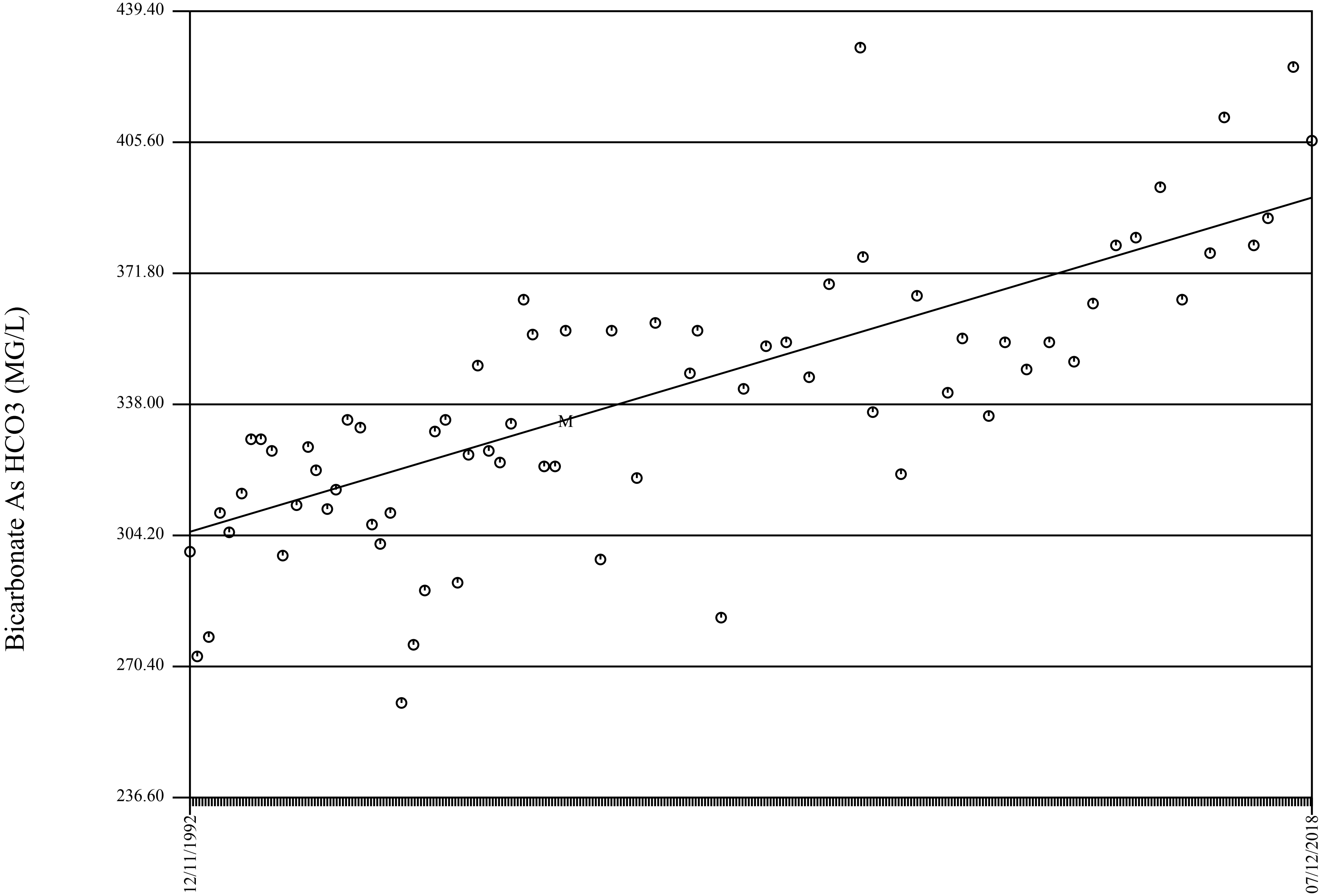
No censored data. 0.1051 Sen trend detected at 10.00% in 90.00% confidence interval 0.0956, 0.1147

ALUV200



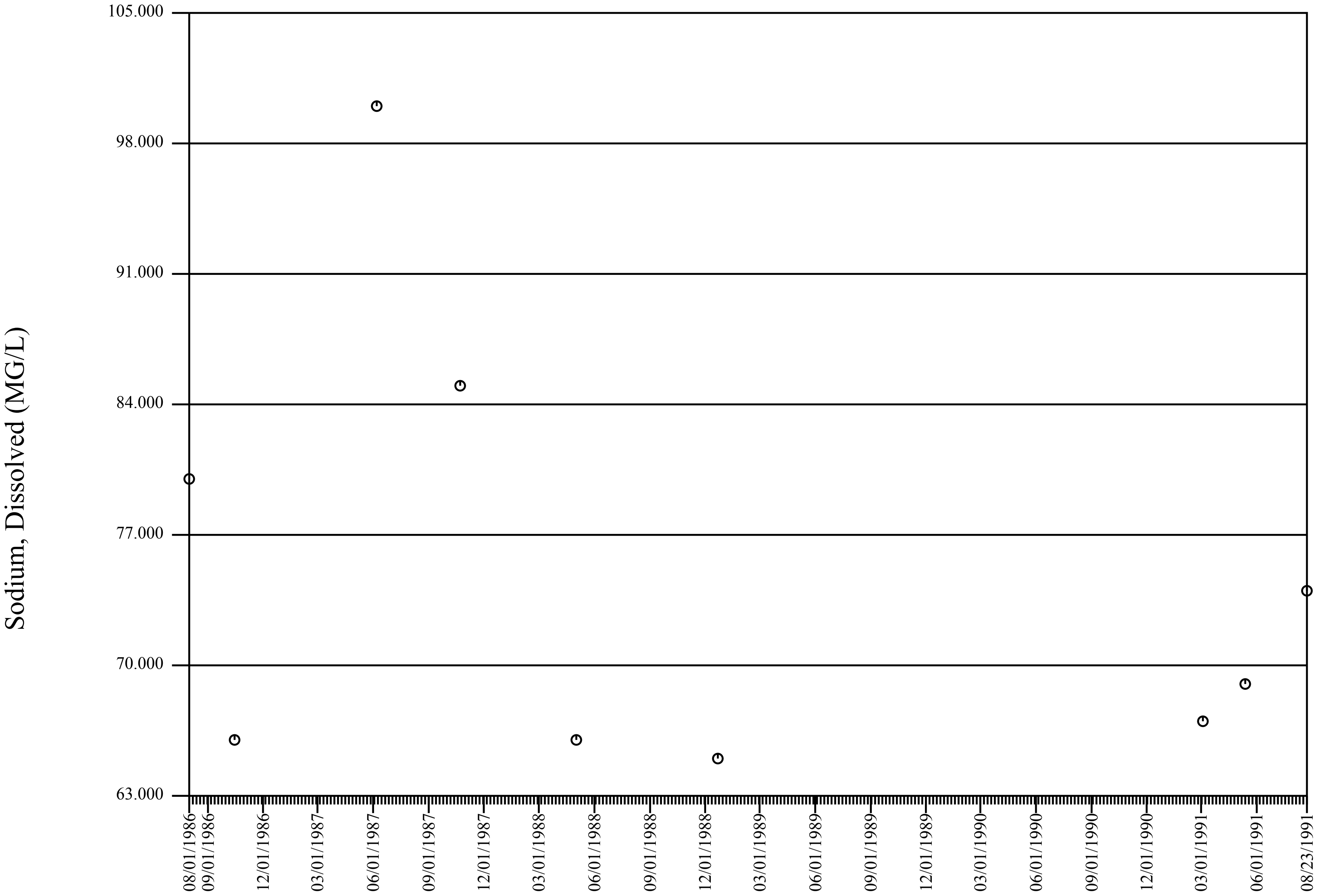
No censored data. 0.0632 Sen trend detected at 10.00% in 90.00% confidence interval 0.0556, 0.0699

ALUV200



No censored data. 0.0092 Sen trend detected at 10.00% in 90.00% confidence interval 0.0077, 0.0109

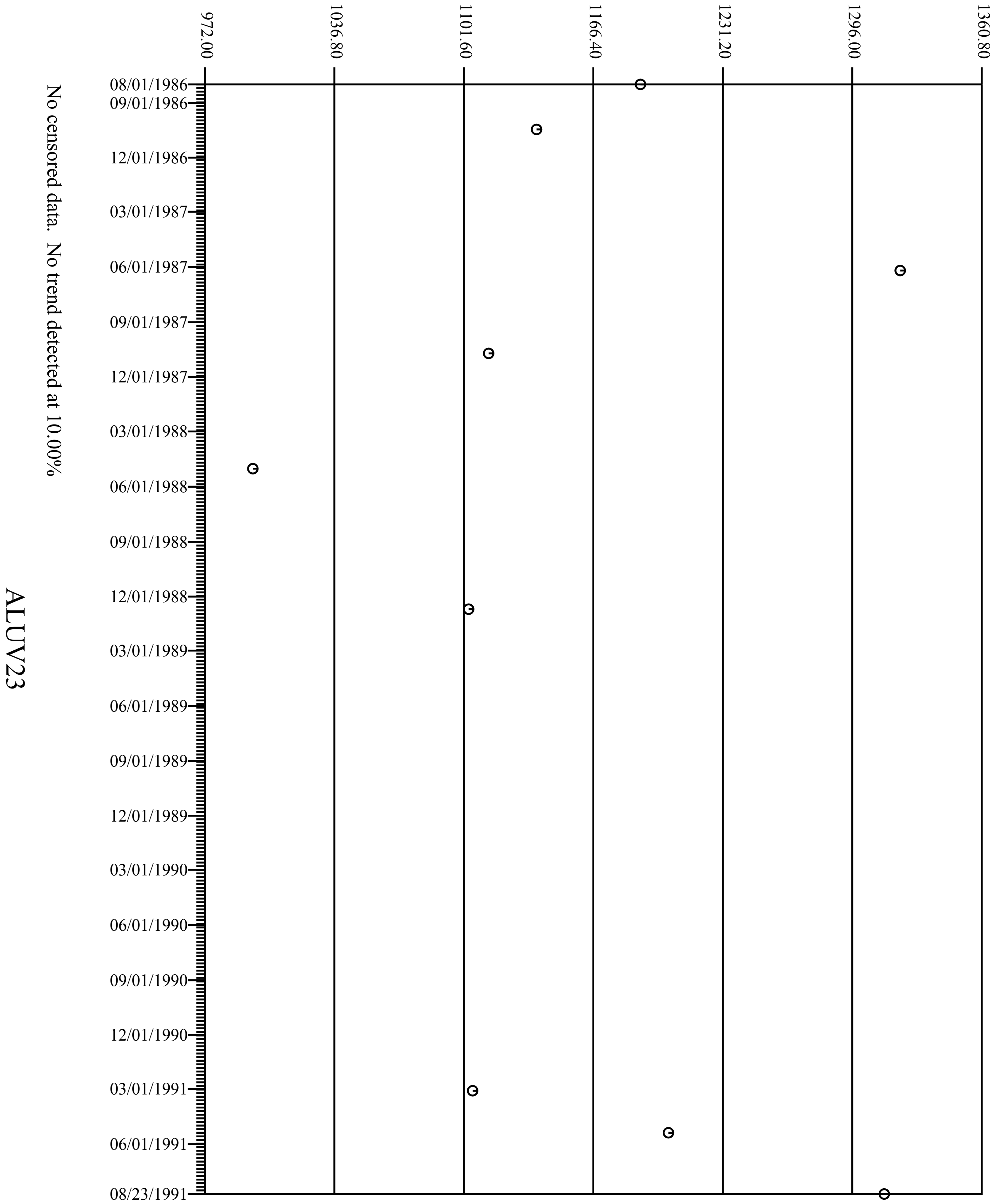
ALUV200



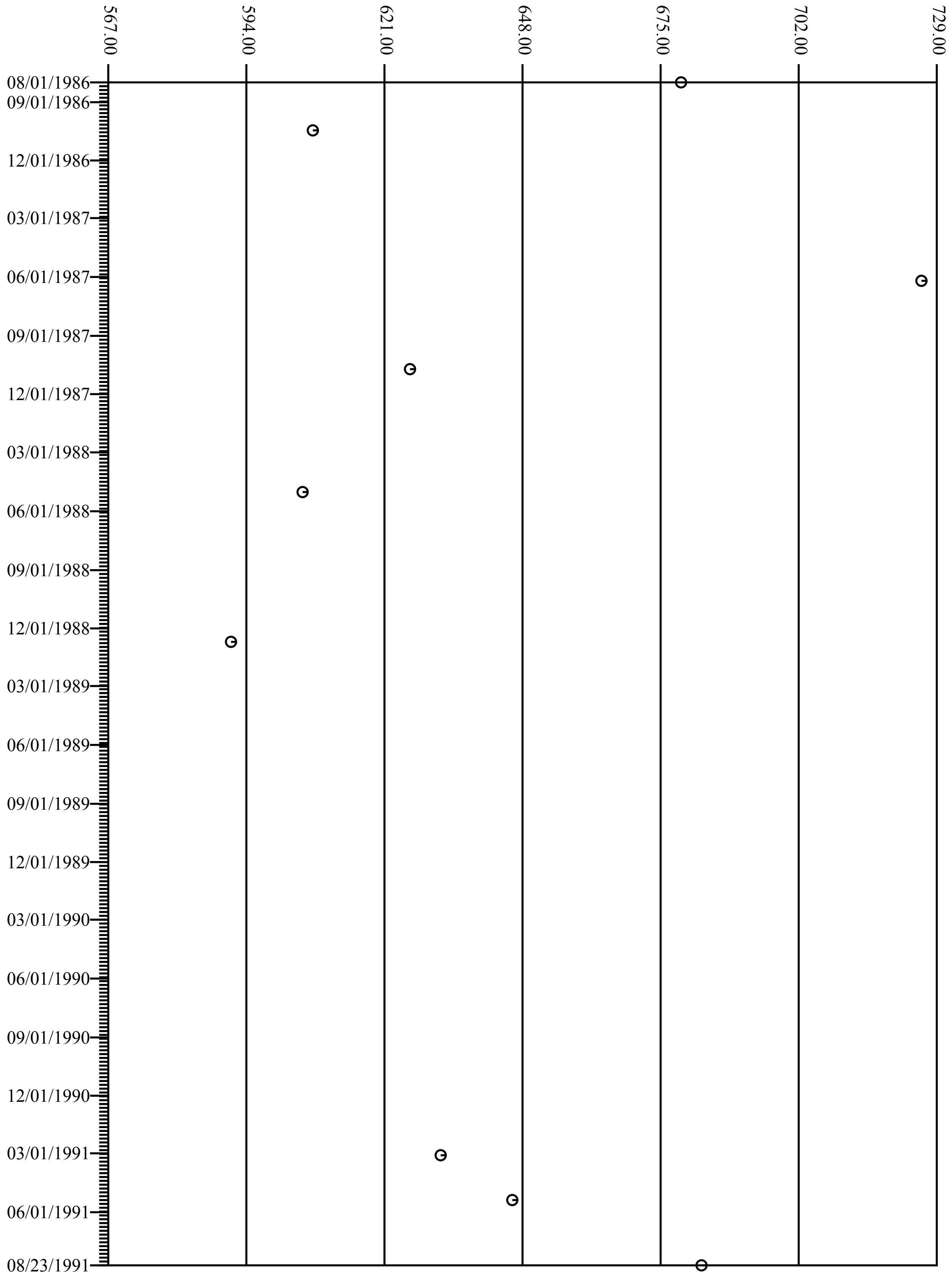
No censored data. No trend detected at 10.00%

ALUV23

Solids, Dissolved (MG/L)

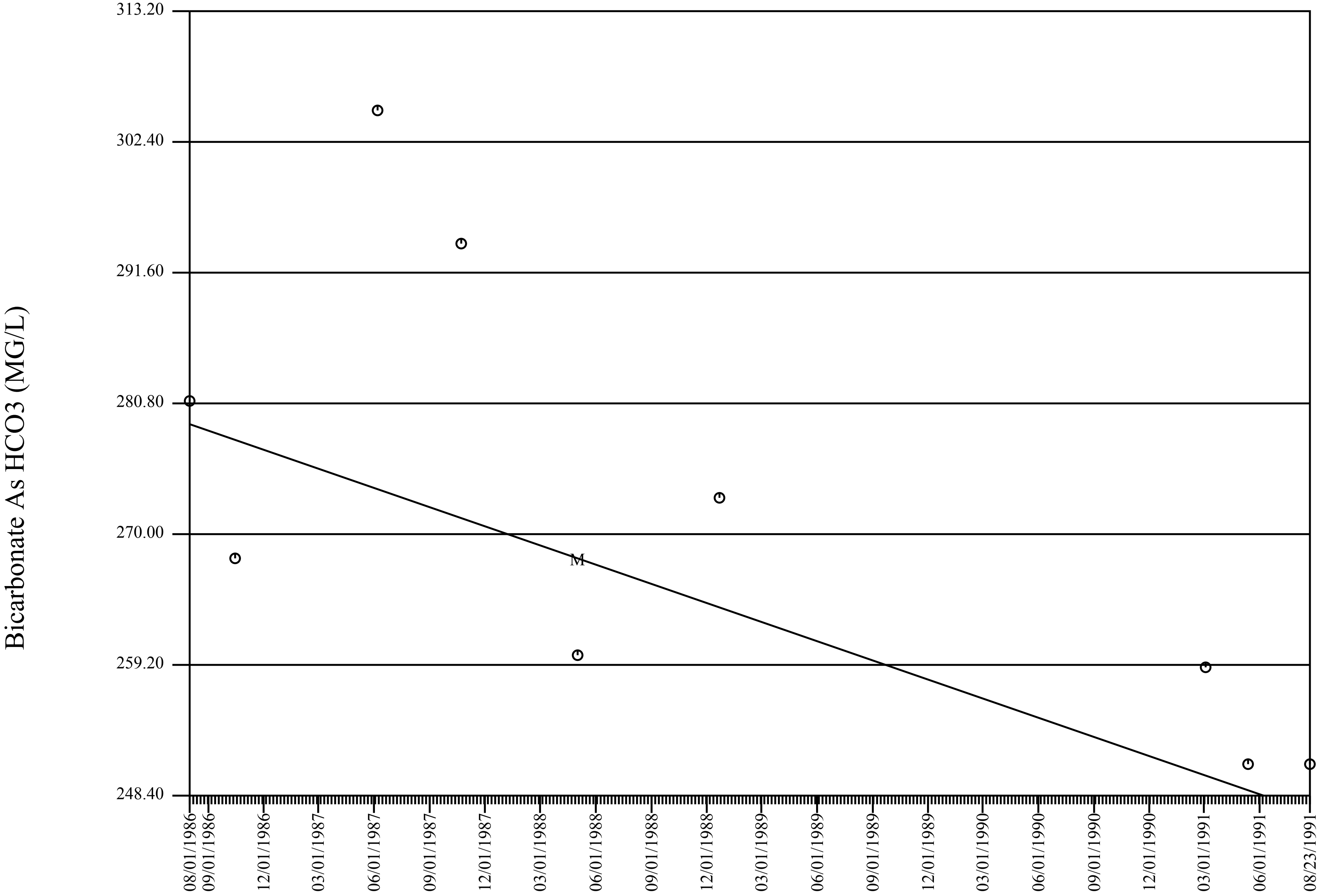


Sulfate (MG/L)



No censored data. No trend detected at 10.00%

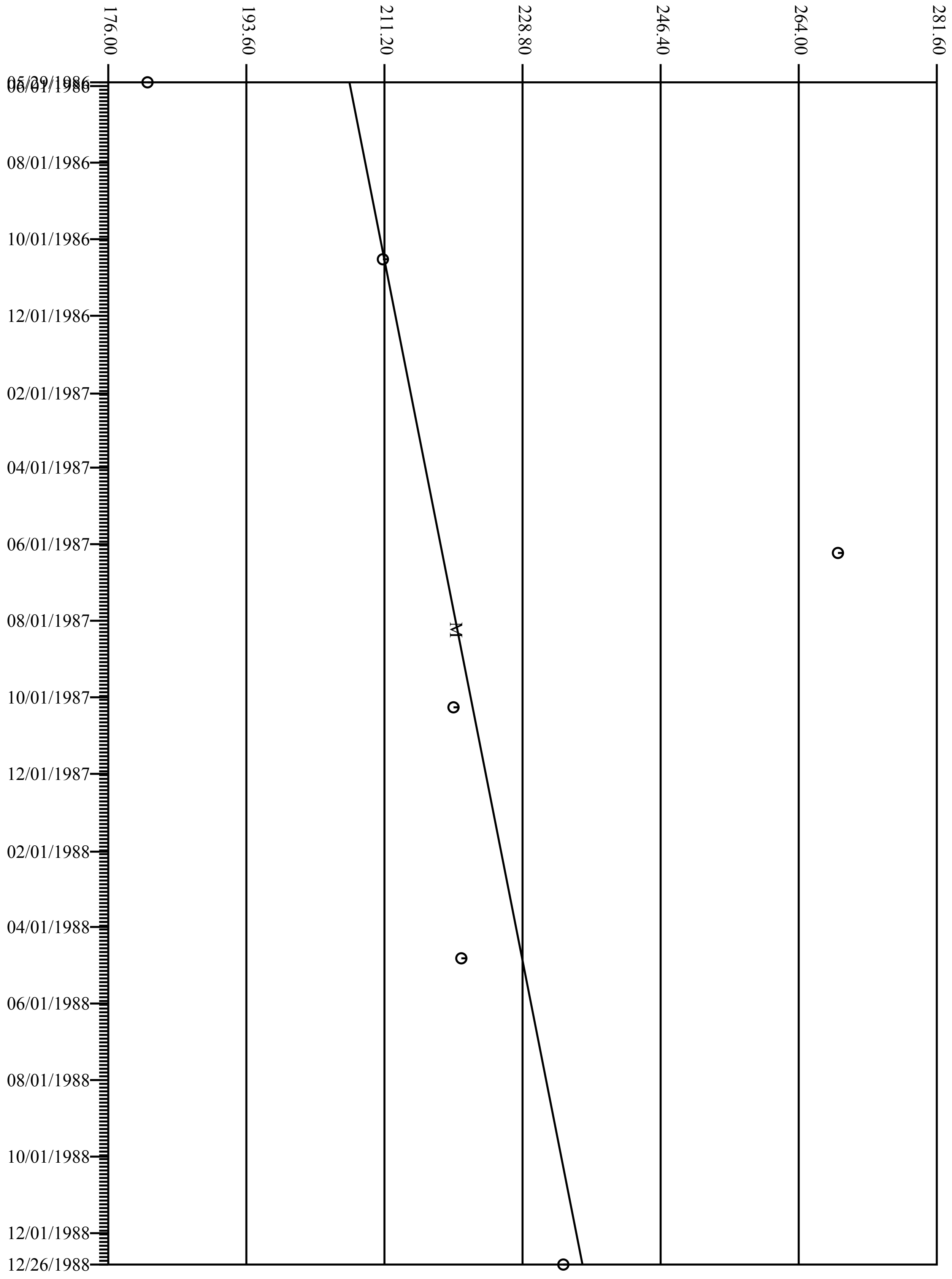
ALUV23



No censored data. -0.0173 Sen trend detected at 10.00% in 90.00% confidence interval -0.0335, -0.0084

ALUV23

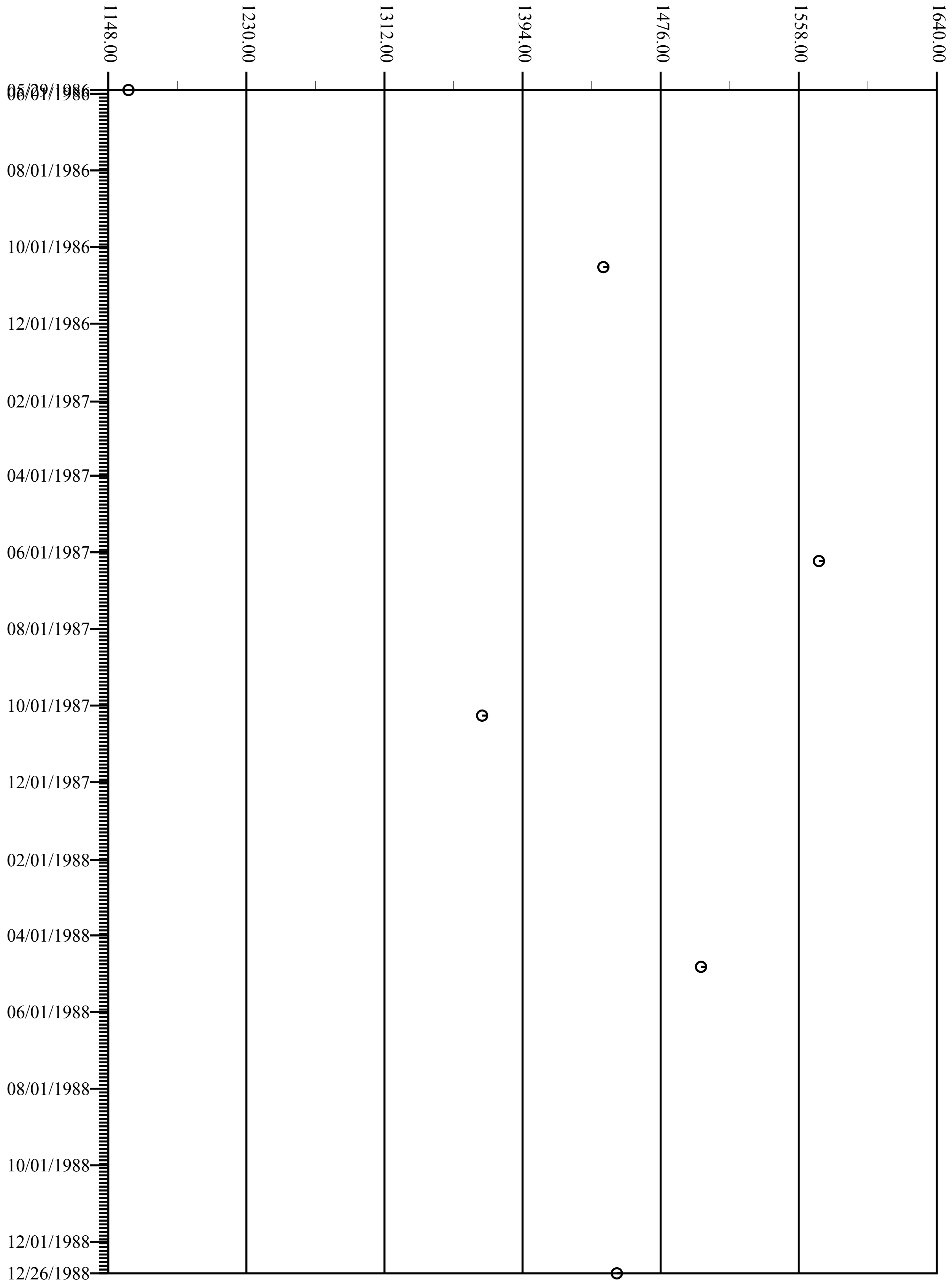
Sodium, Dissolved (MG/L)



No censored data. 0.0315 Sen trend detected at 10.00% in 90.00% confidence interval -0.0303, 0.1495

ALUV27

Solids, Dissolved (MG/L)

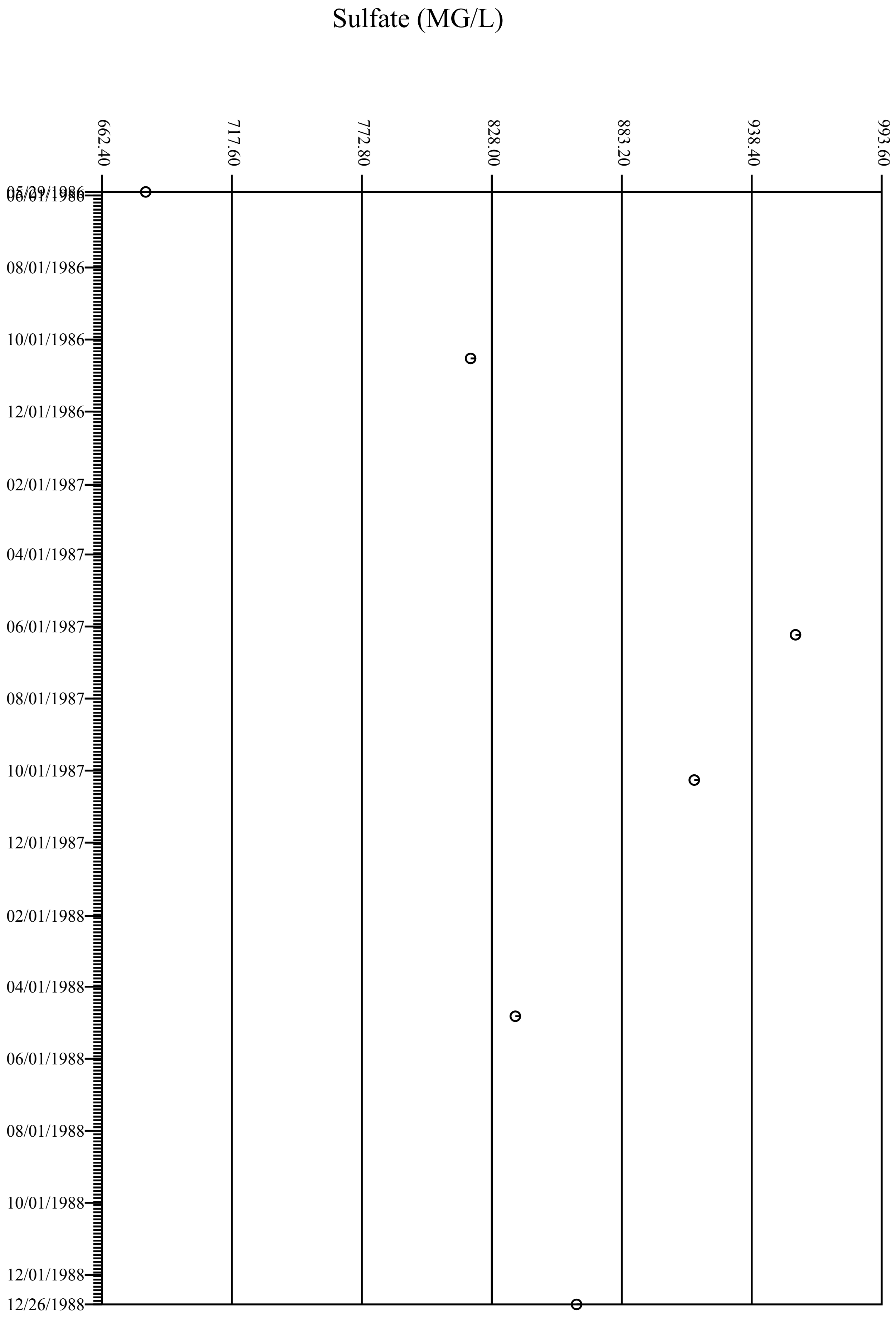


No censored data. No trend detected at 10.00%

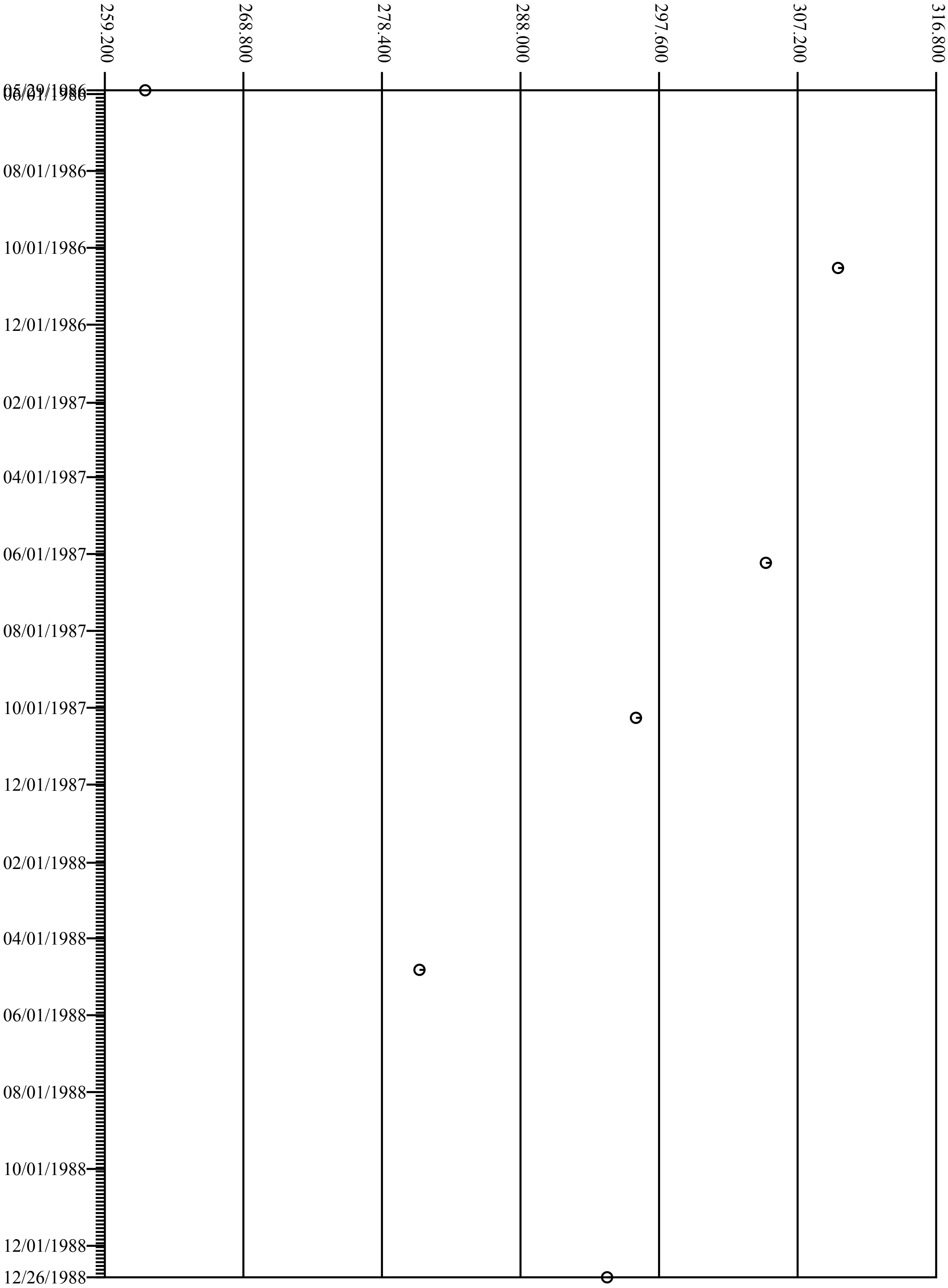
ALUV27

ALUV27

No censored data. No trend detected at 10.00%

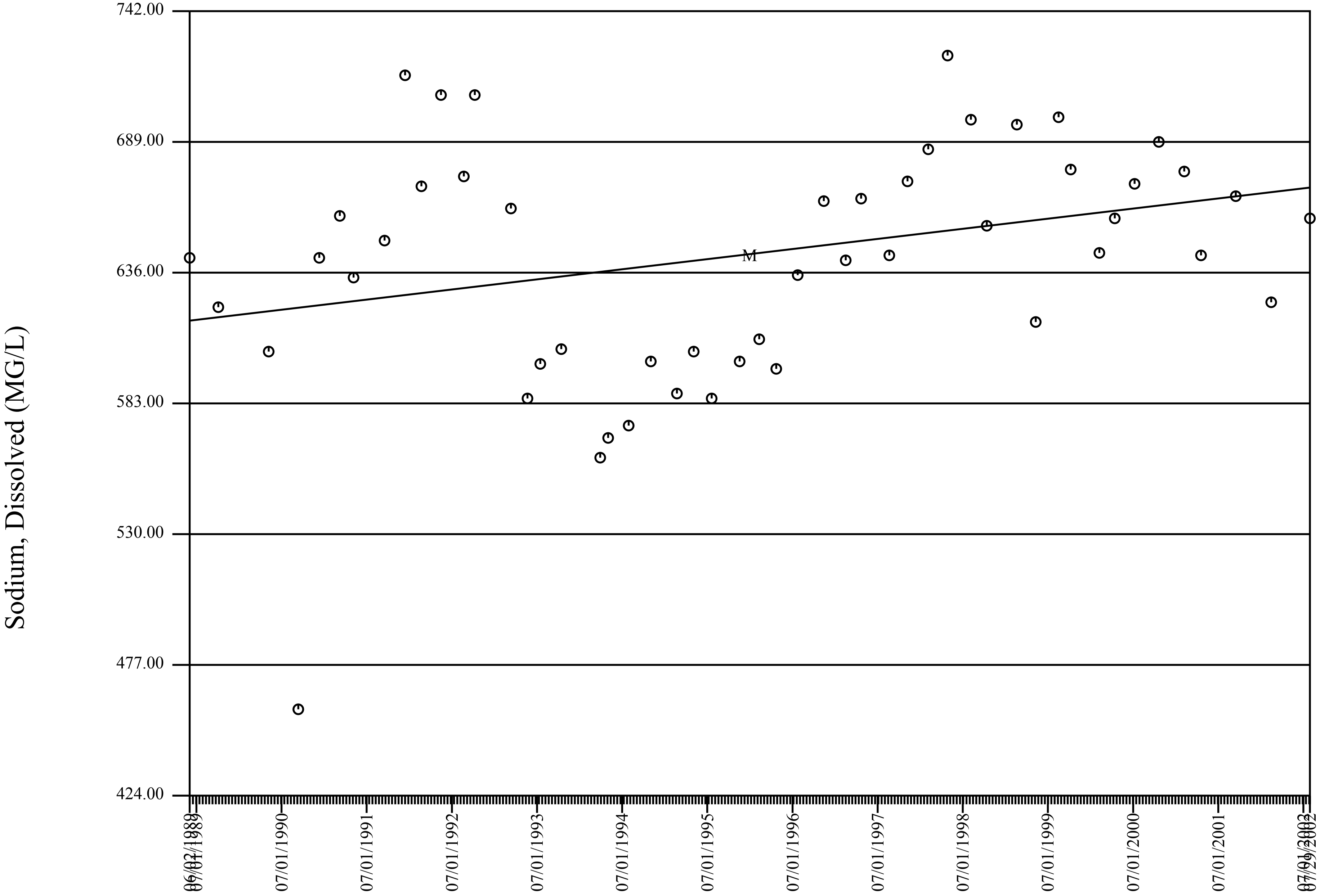


Bicarbonate As HCO3 (MG/L)



No censored data. No trend detected at 10.00%

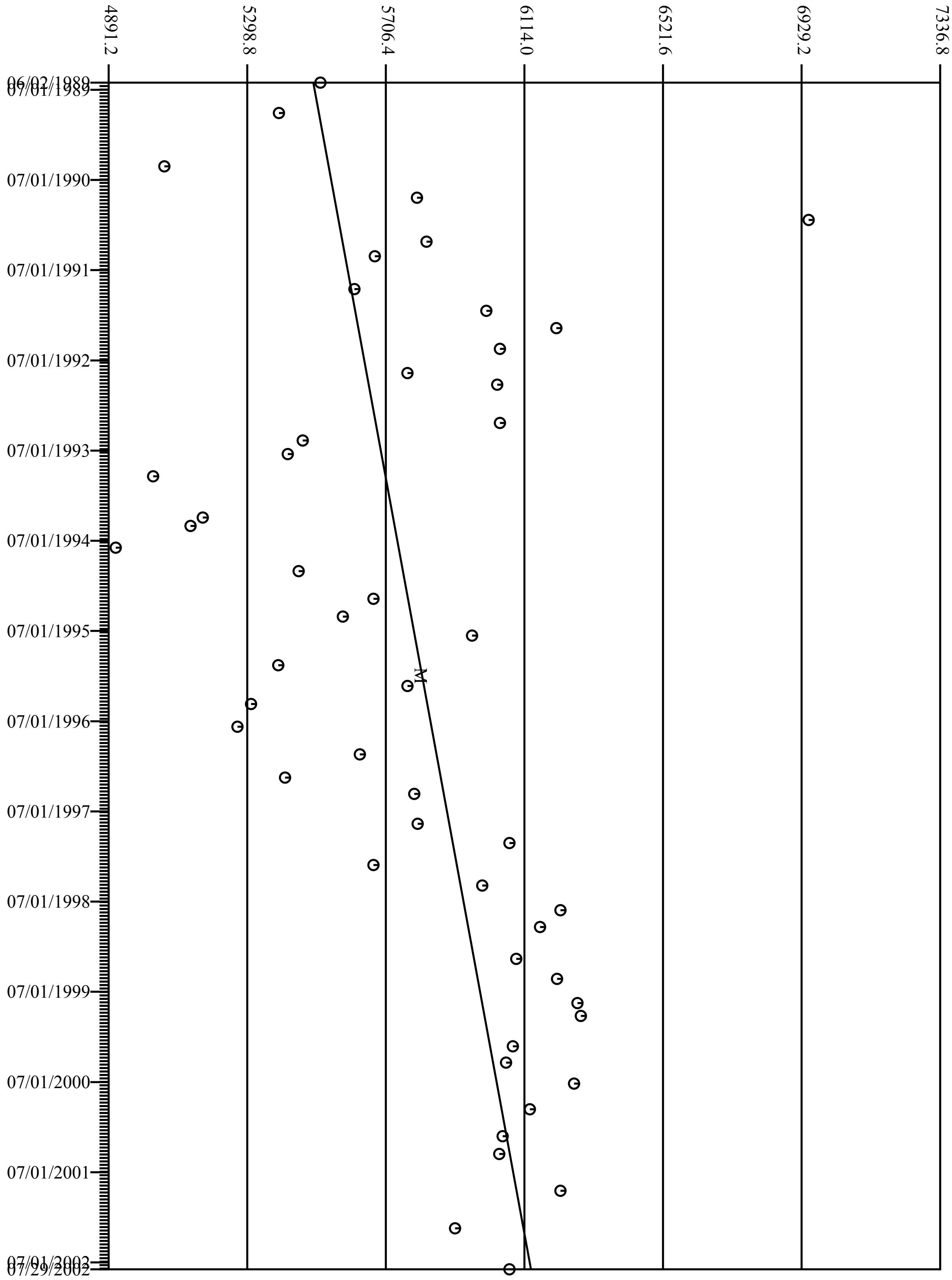
ALUV27



No censored data. 0.0112 Sen trend detected at 10.00% in 90.00% confidence interval 0.0032, 0.0216

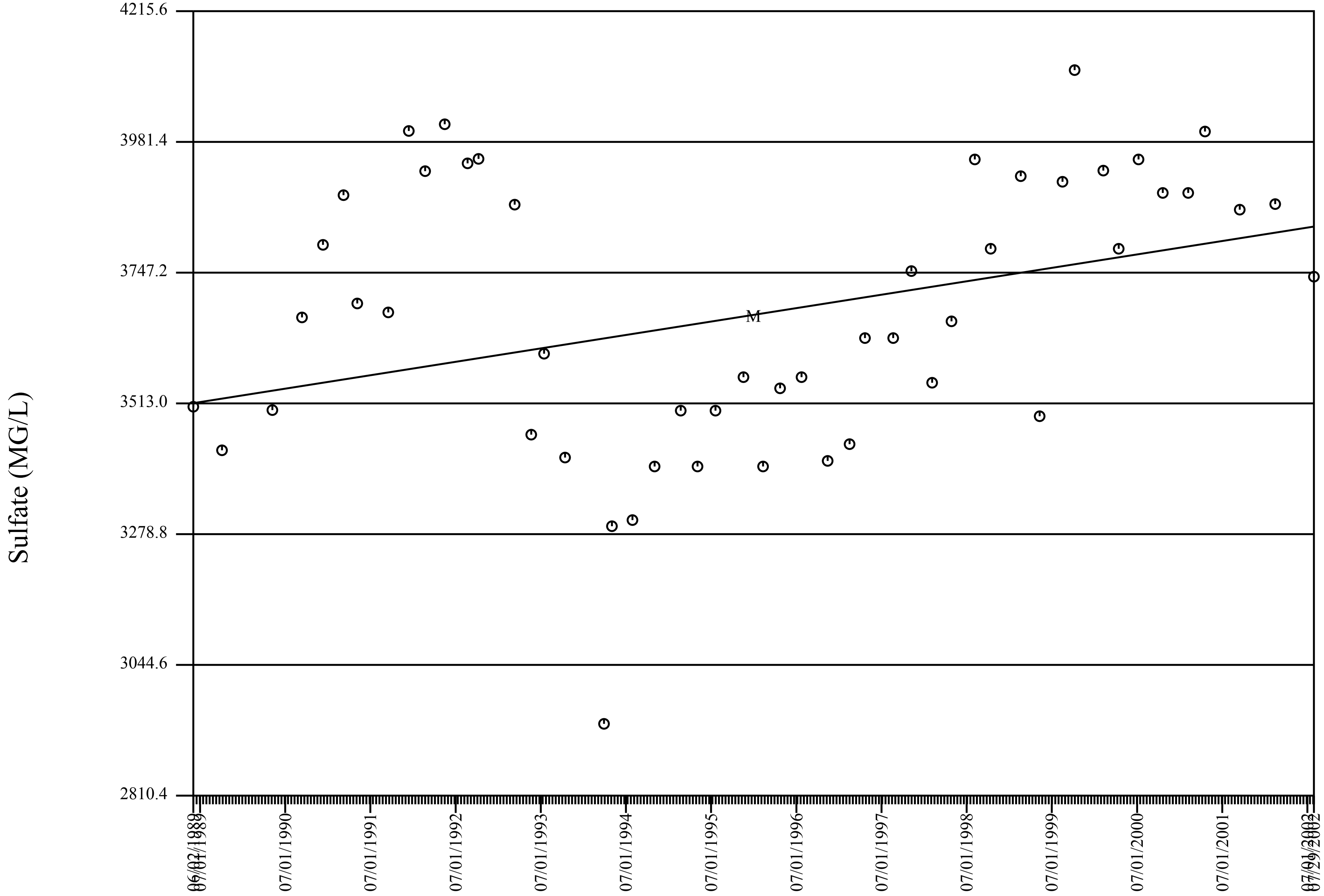
ALUV27R

Solids, Dissolved (MG/L)



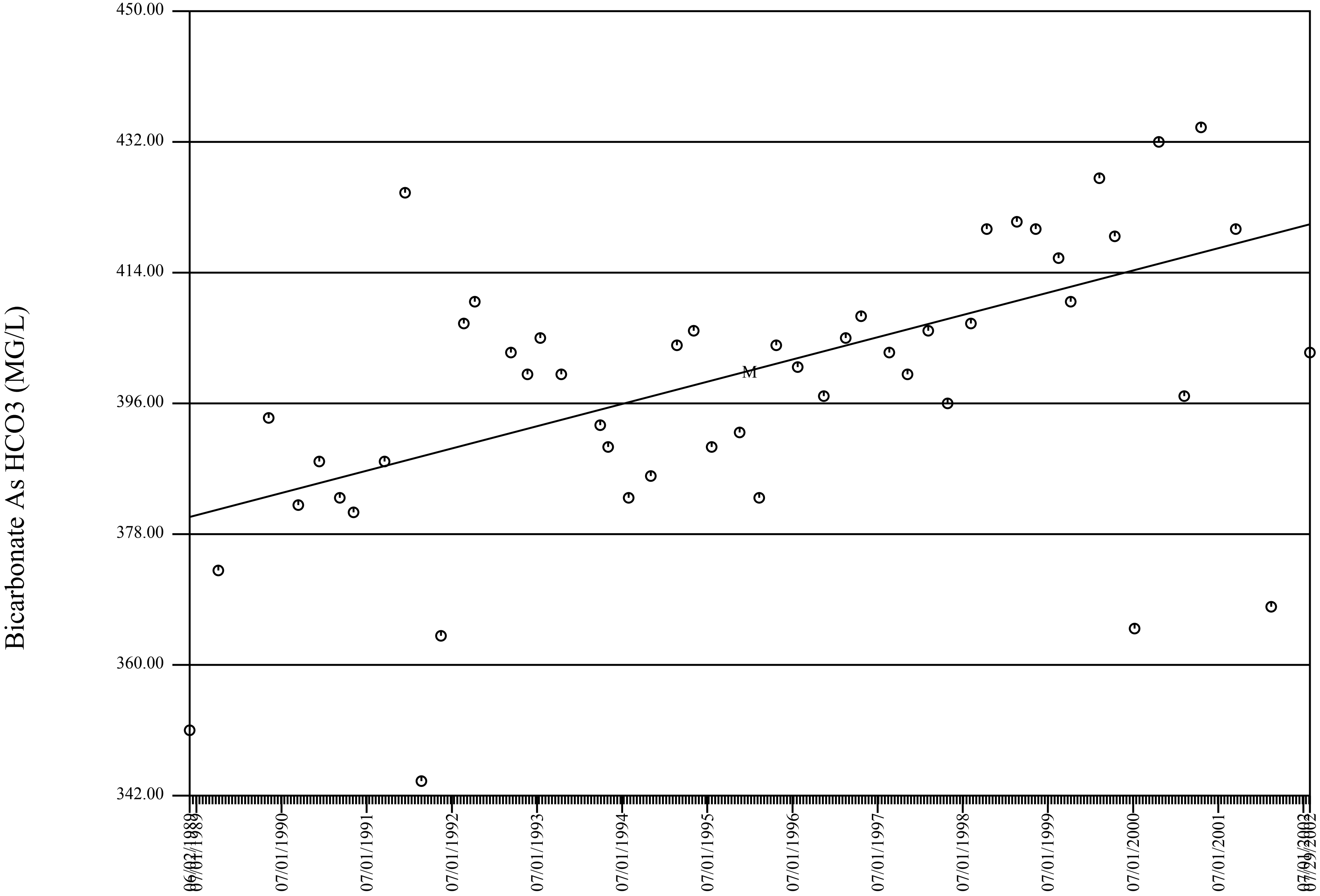
No censored data. 0.1332 Sen trend detected at 10.00% in 90.00% confidence interval 0.0677, 0.2007

ALUV27R



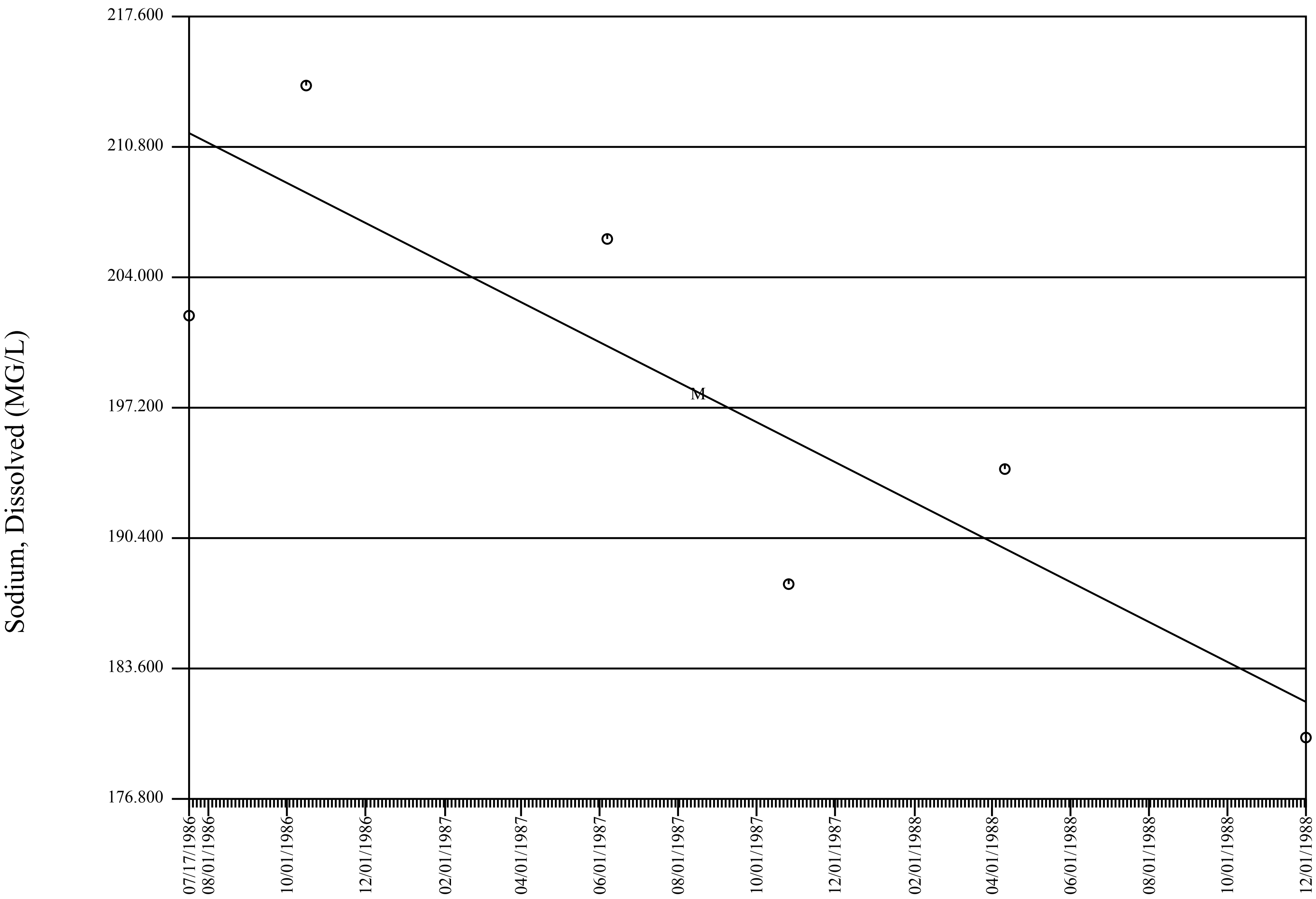
No censored data. 0.0658 Sen trend detected at 10.00% in 90.00% confidence interval 0.0160, 0.1190

ALUV27R



No censored data. 0.0084 Sen trend detected at 10.00% in 90.00% confidence interval 0.0053, 0.0110

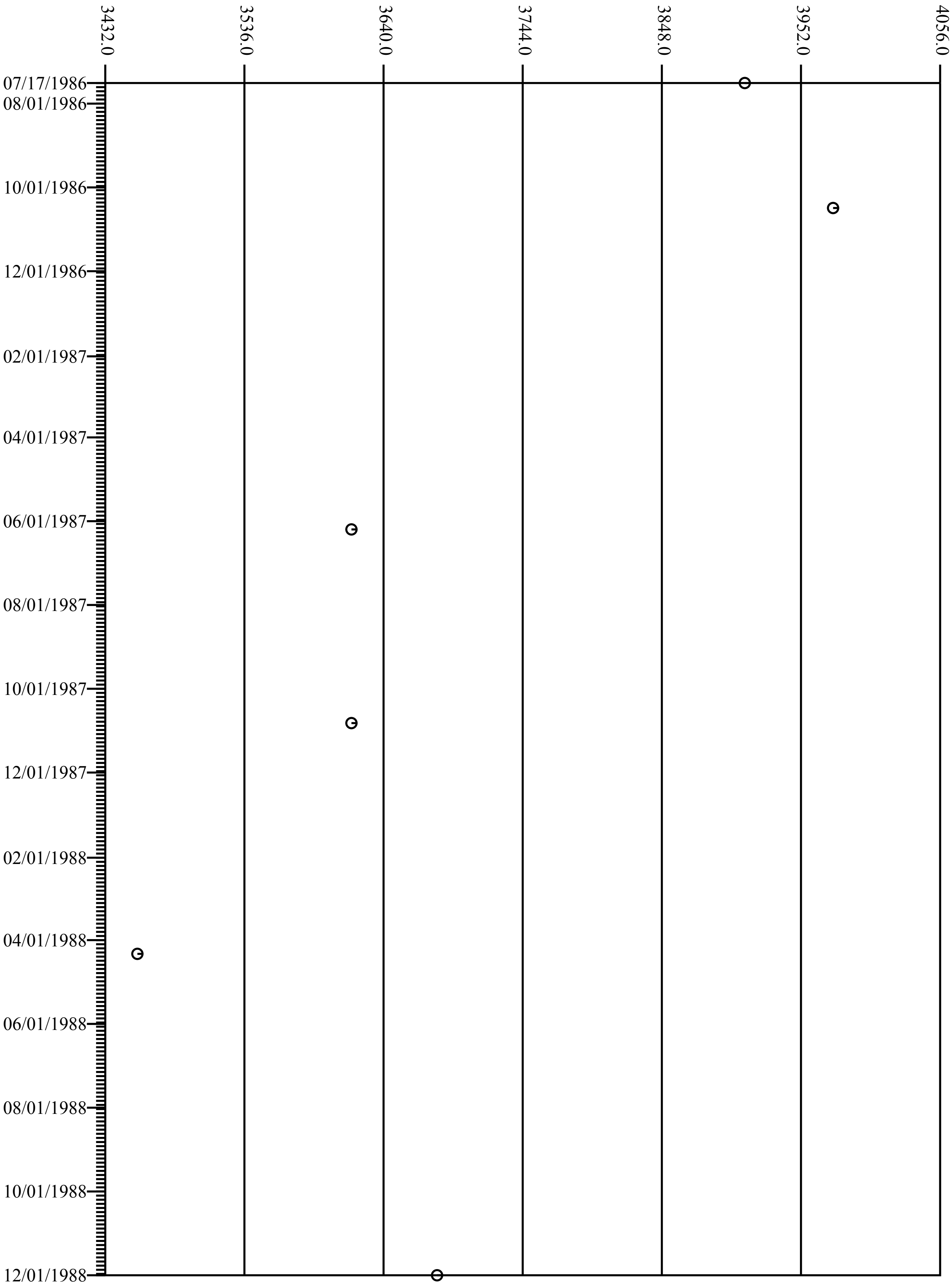
ALUV27R



No censored data. -0.0342 Sen trend detected at 10.00% in 90.00% confidence interval -0.0542, 0.0006

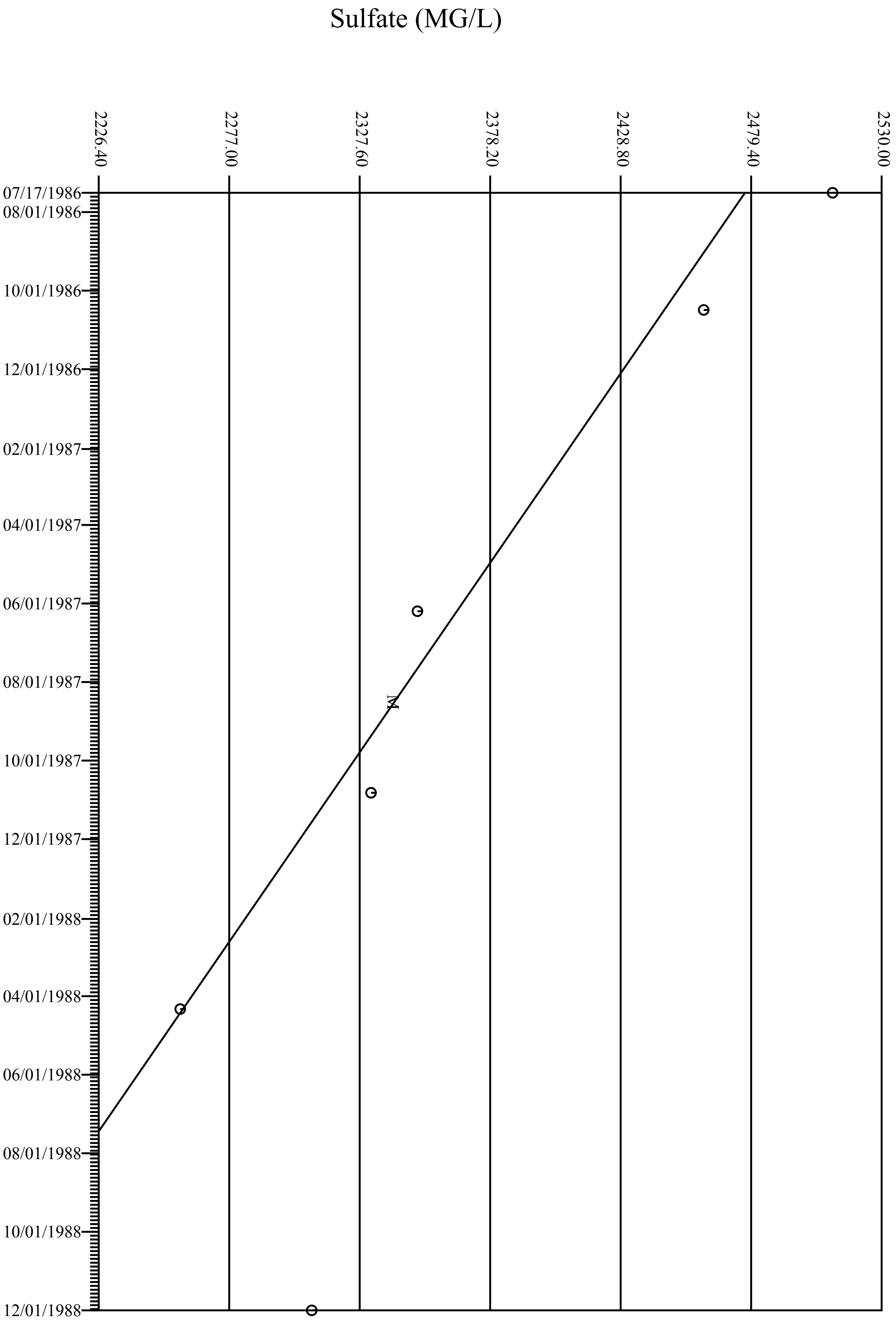
ALUV80

Solids, Dissolved (MG/L)



No censored data. No trend detected at 10.00%

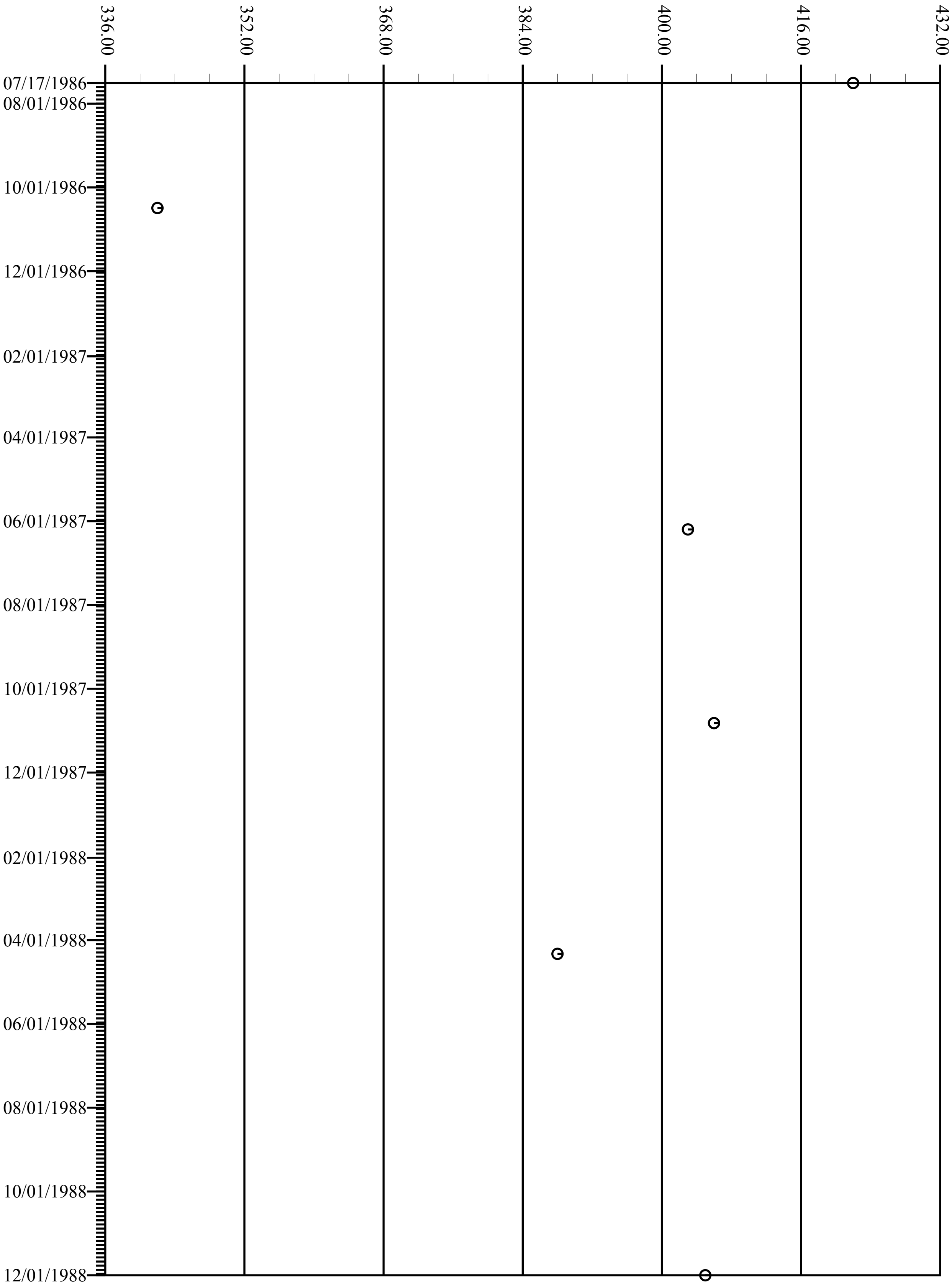
ALUV80



No censored data. -0.3438 Sen trend detected at 10.00% in 90.00% confidence interval -0.4585, -0.1000

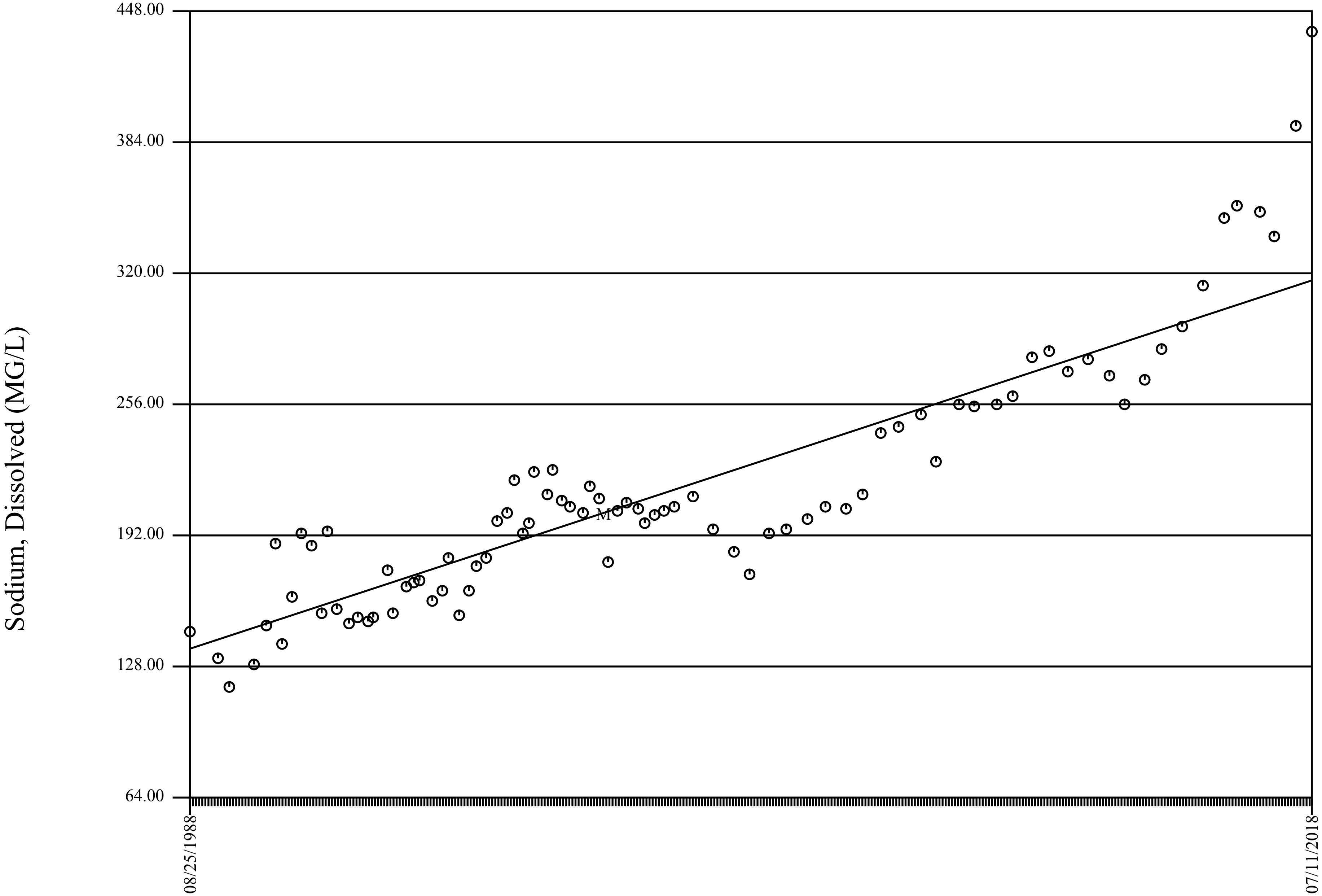
ALUV80

Bicarbonate As HCO3 (MG/L)



No censored data. No trend detected at 10.00%

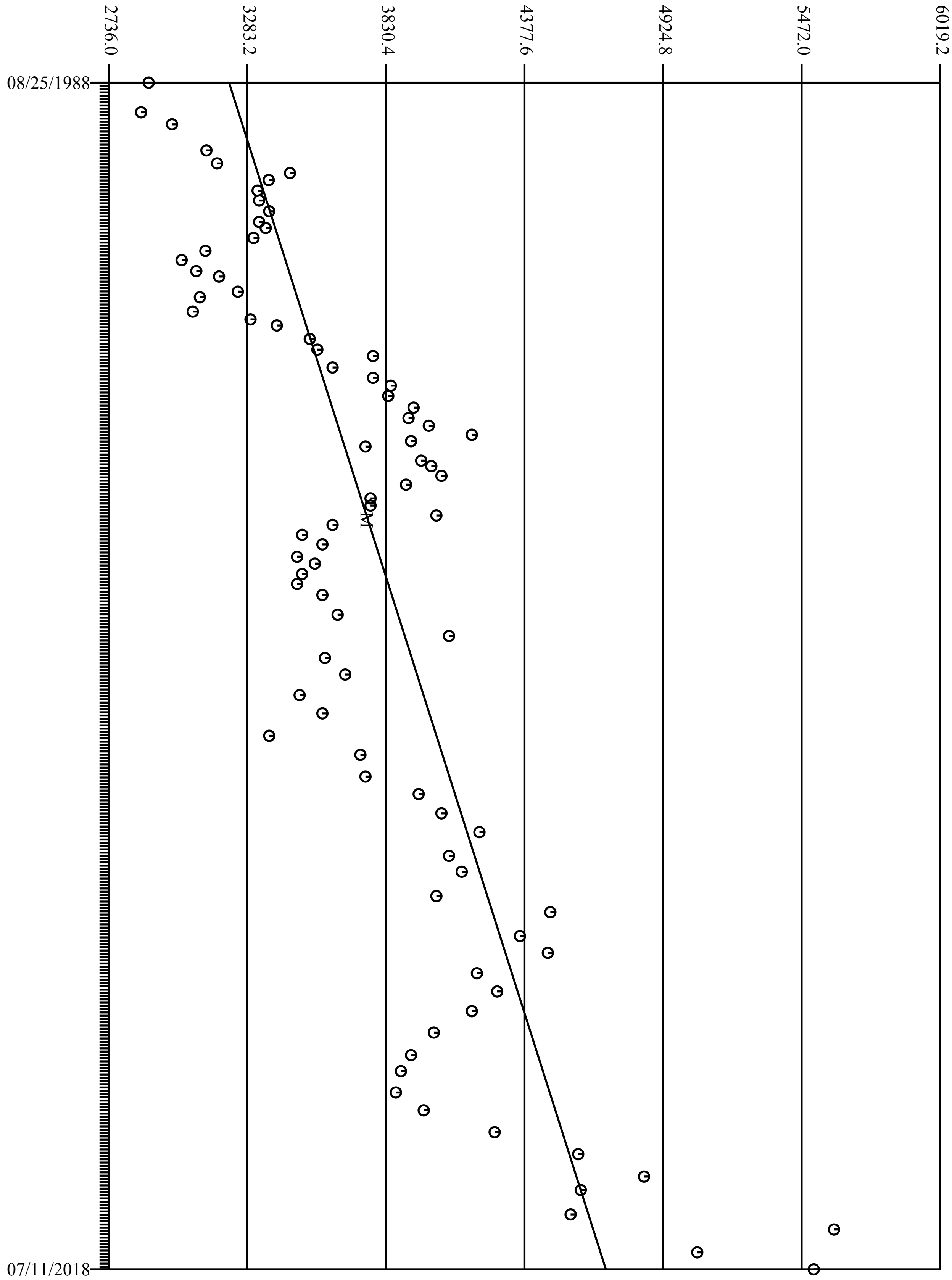
ALUV80



No censored data. 0.0165 Sen trend detected at 10.00% in 90.00% confidence interval 0.0150, 0.0178

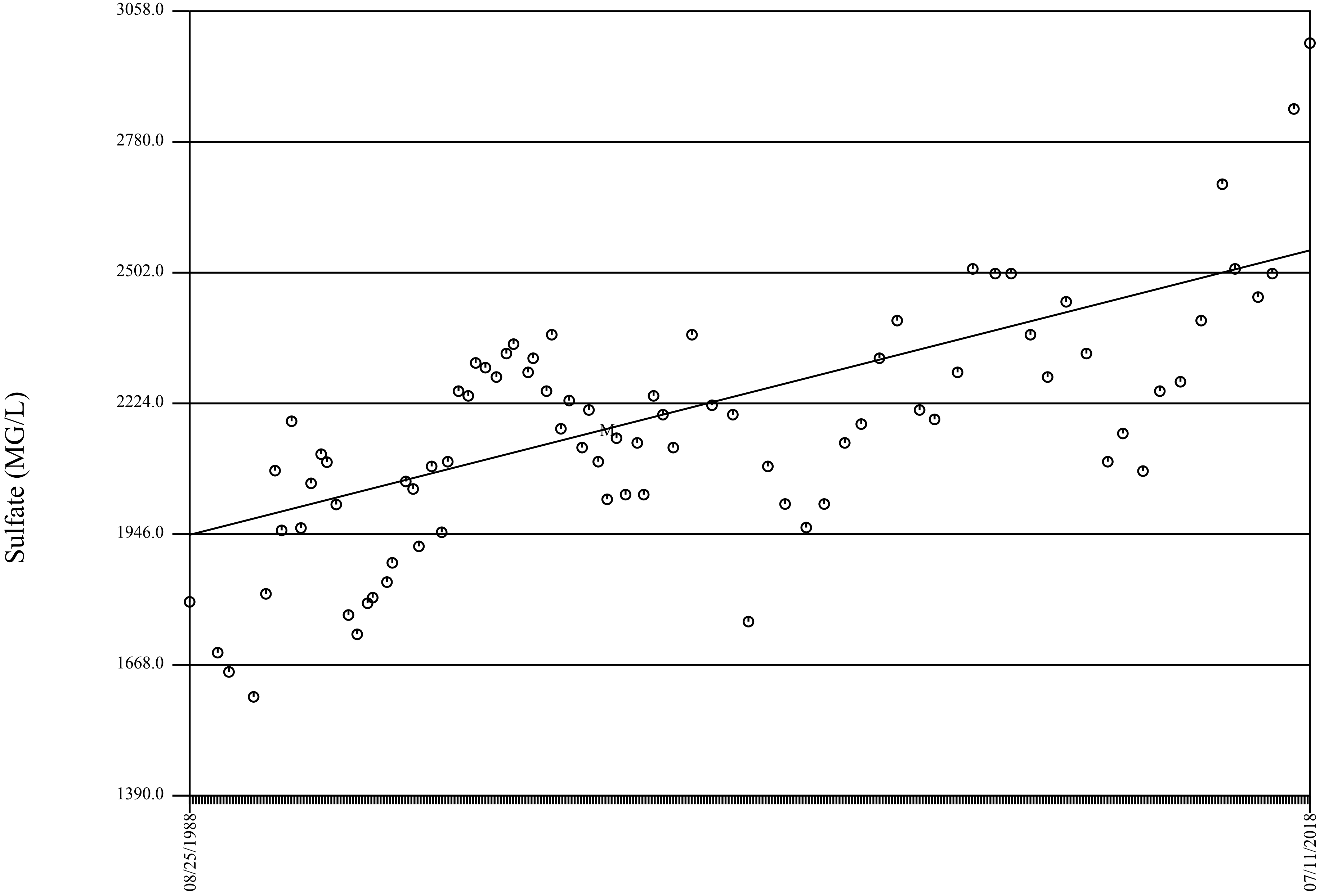
ALUV80R

Solids, Dissolved (MG/L)



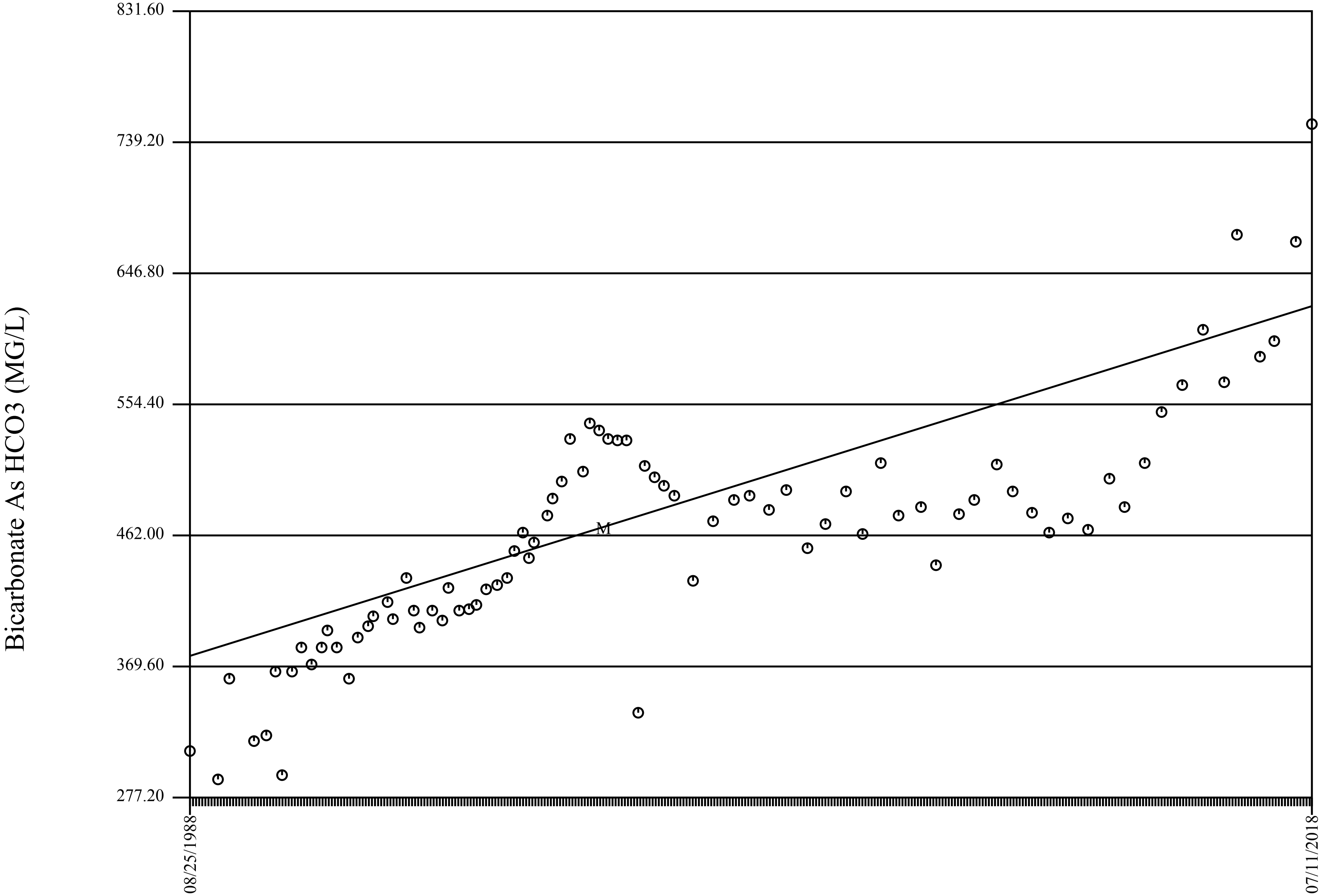
No censored data. 0.1363 Sen trend detected at 10.00% in 90.00% confidence interval 0.1148, 0.1558

ALUV80R



No censored data. 0.0554 Sen trend detected at 10.00% in 90.00% confidence interval 0.0439, 0.0681

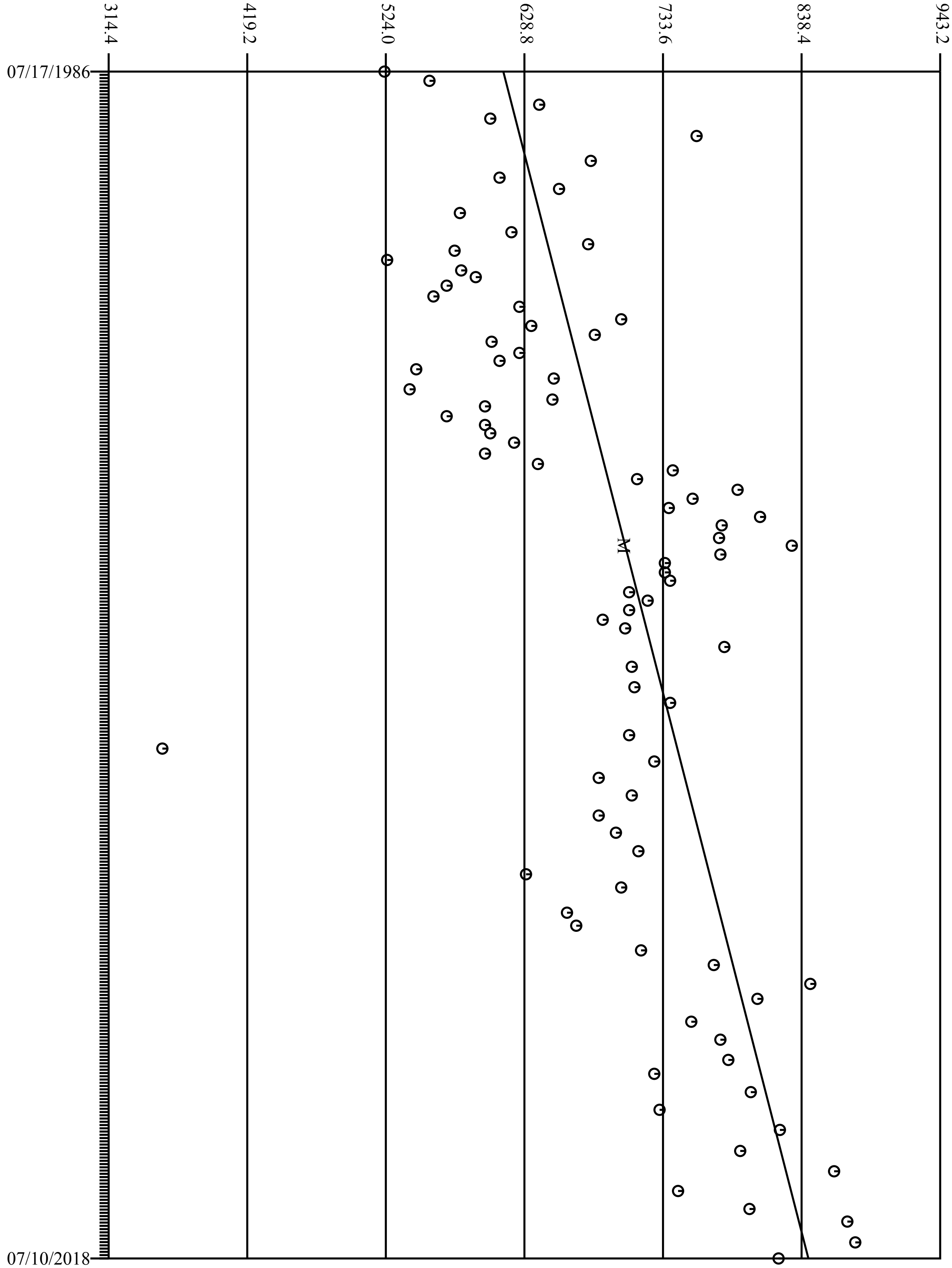
ALUV80R



No censored data. 0.0226 Sen trend detected at 10.00% in 90.00% confidence interval 0.0197, 0.0258

ALUV80R

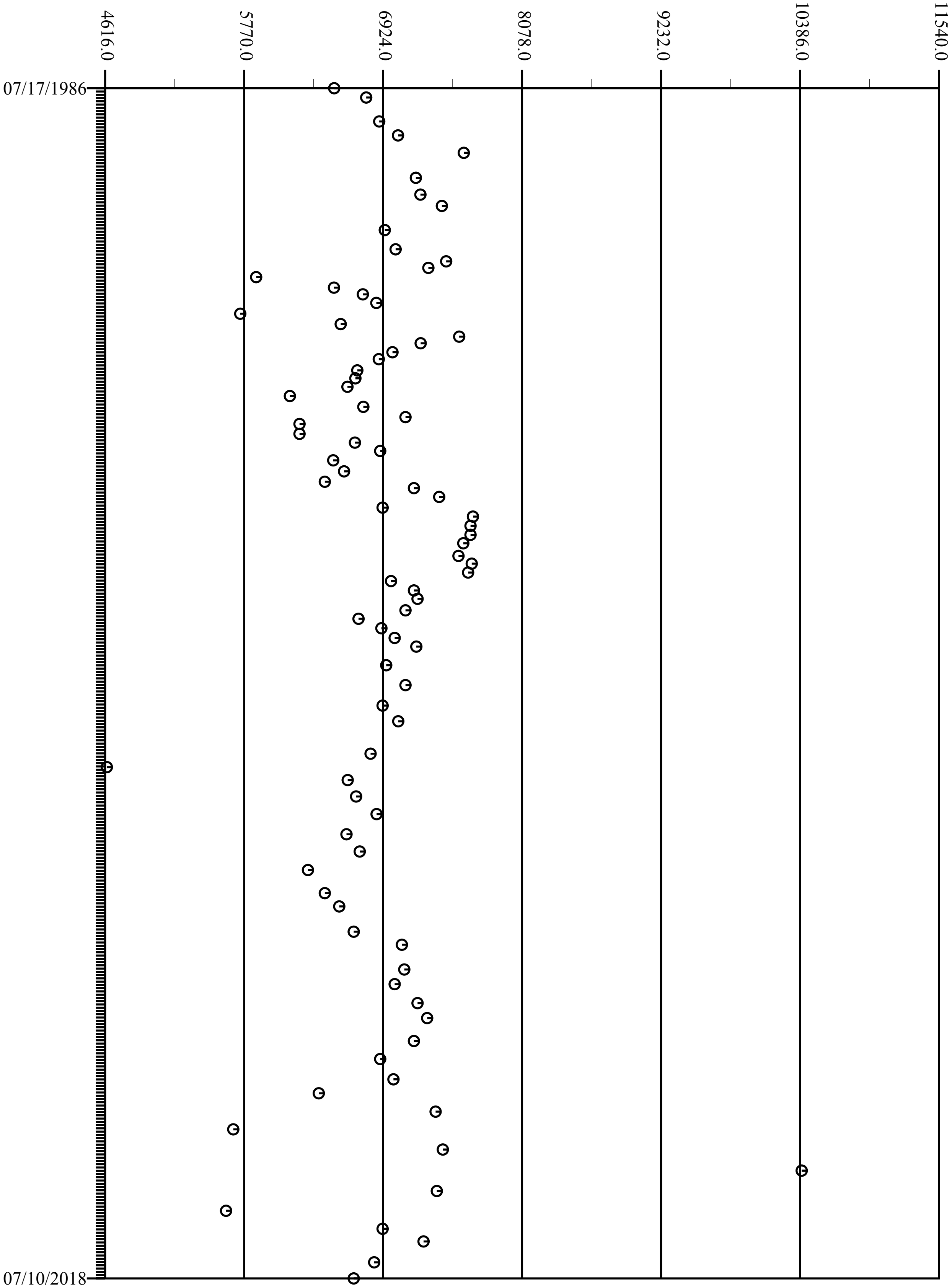
Sodium, Dissolved (MG/L)



No censored data. 0.0198 Sen trend detected at 10.00% in 90.00% confidence interval 0.0164, 0.0234

ALUV83

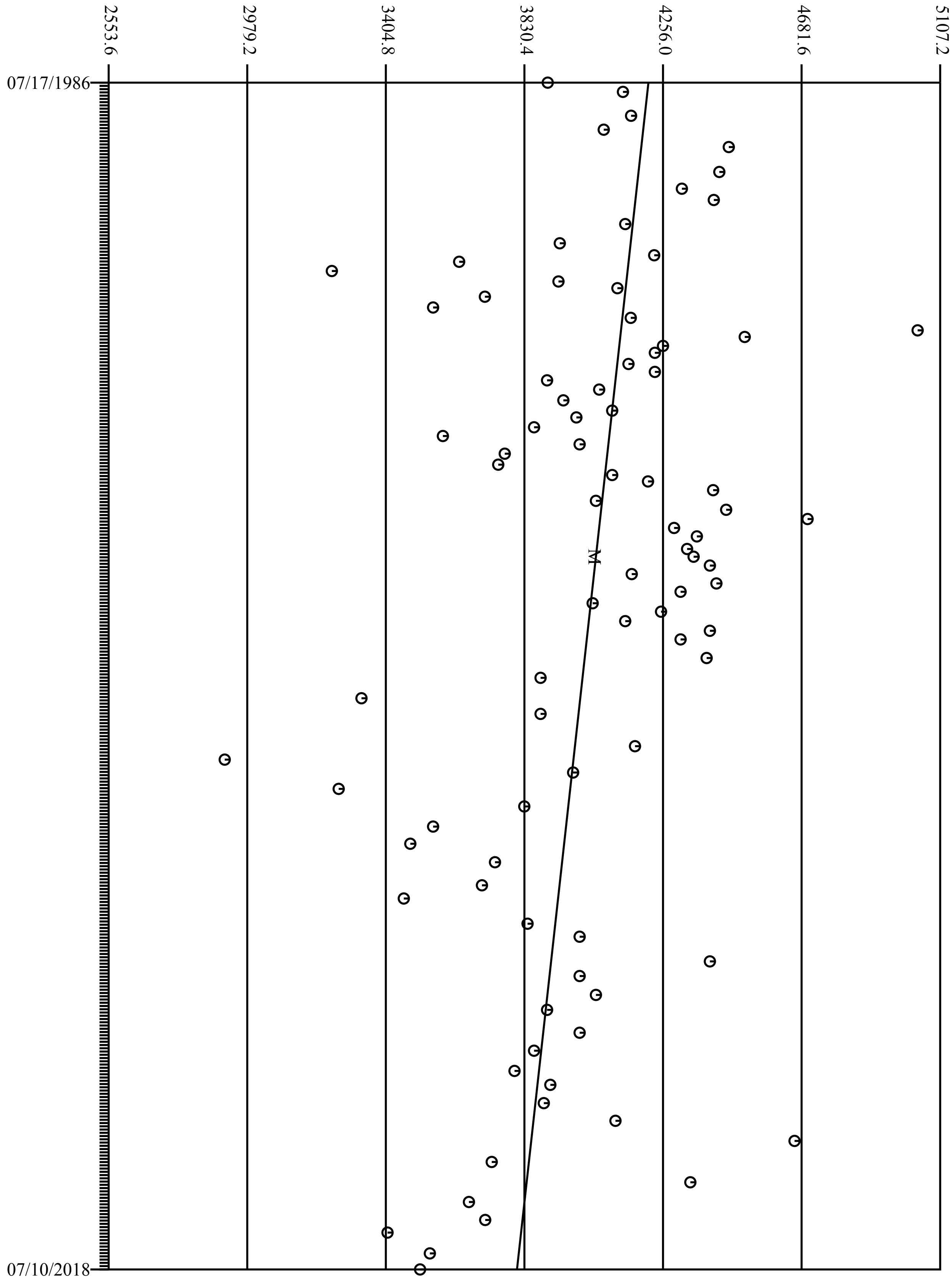
Solids, Dissolved (MG/L)



No censored data. No trend detected at 10.00%

ALUV83

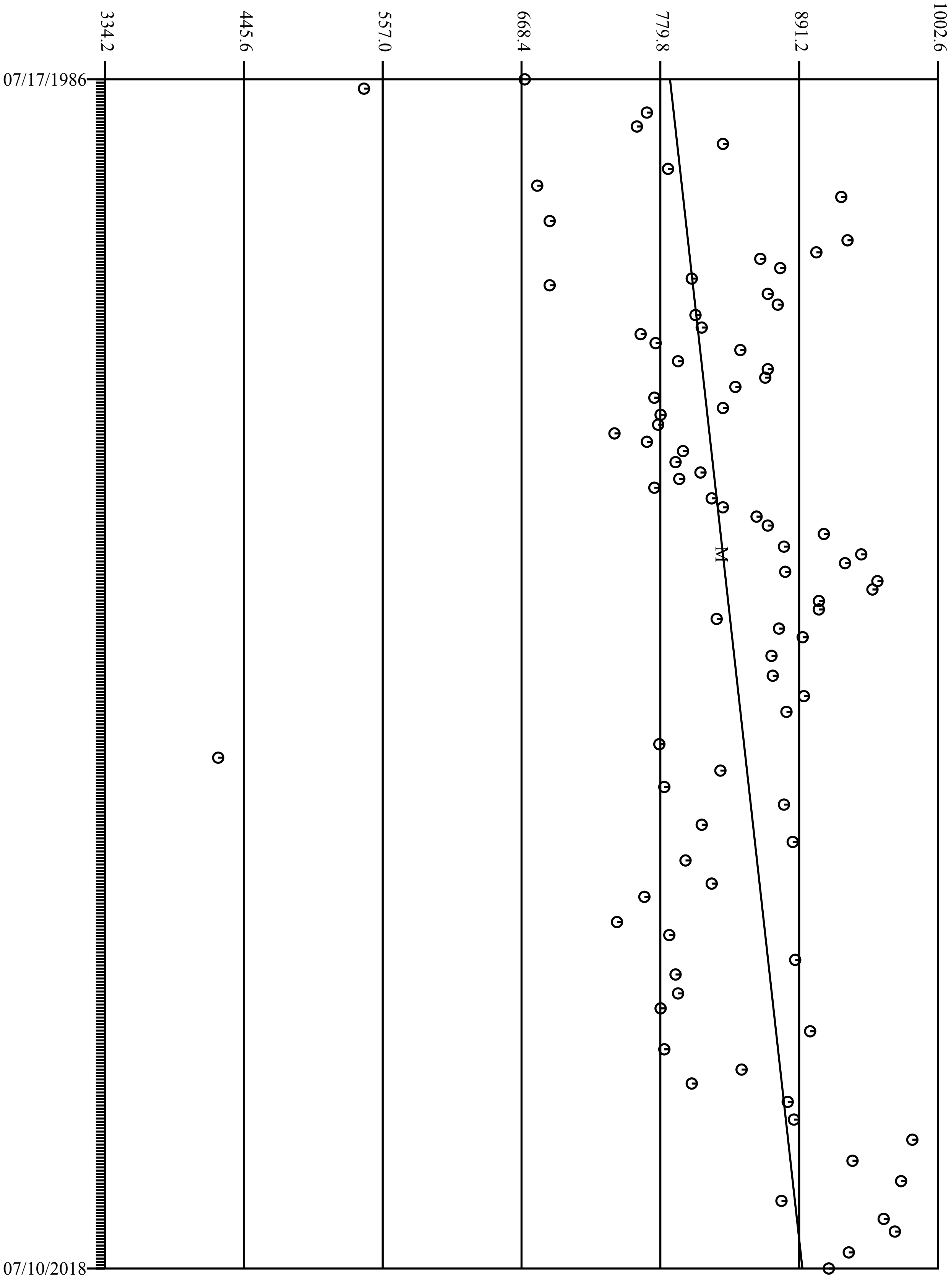
Sulfate (MG/L)



No censored data. -0.0346 Sen trend detected at 10.00% in 90.00% confidence interval -0.0523, -0.0154

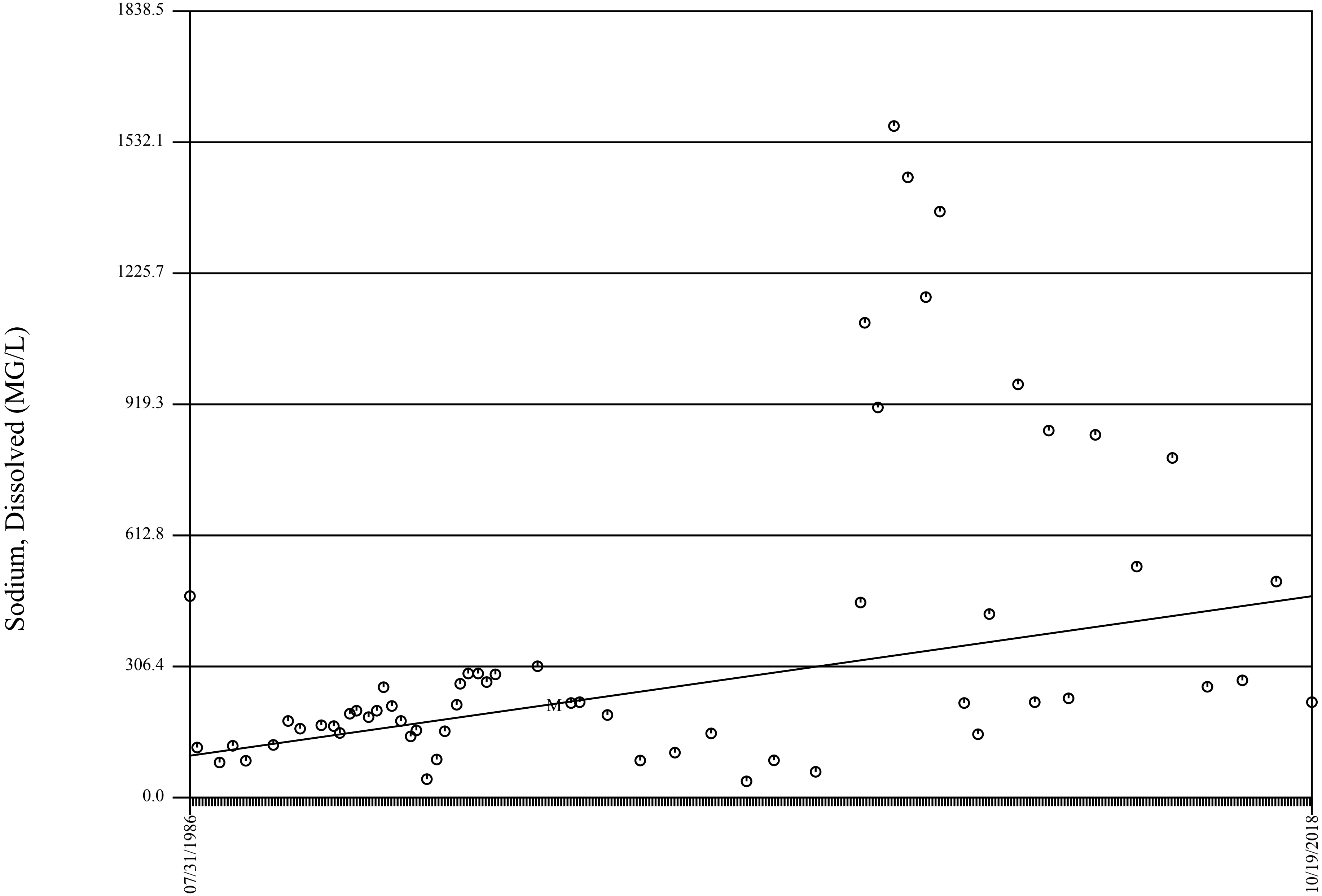
ALUV83

Bicarbonate As HCO3 (MG/L)



No censored data. 0.0091 Sen trend detected at 10.00% in 90.00% confidence interval 0.0046, 0.0136

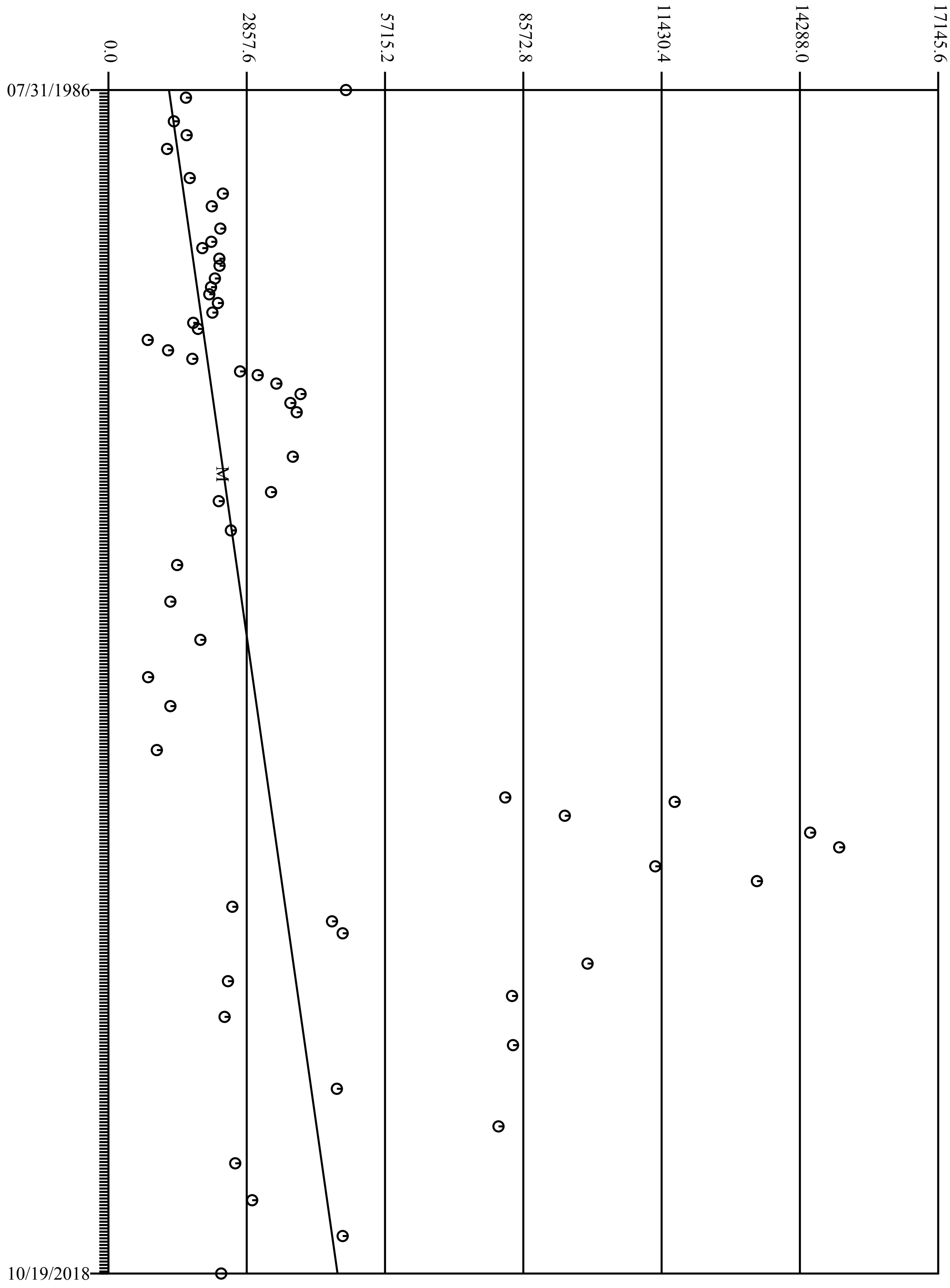
ALUV83



No censored data. 0.0317 Sen trend detected at 10.00% in 90.00% confidence interval 0.0145, 0.0478

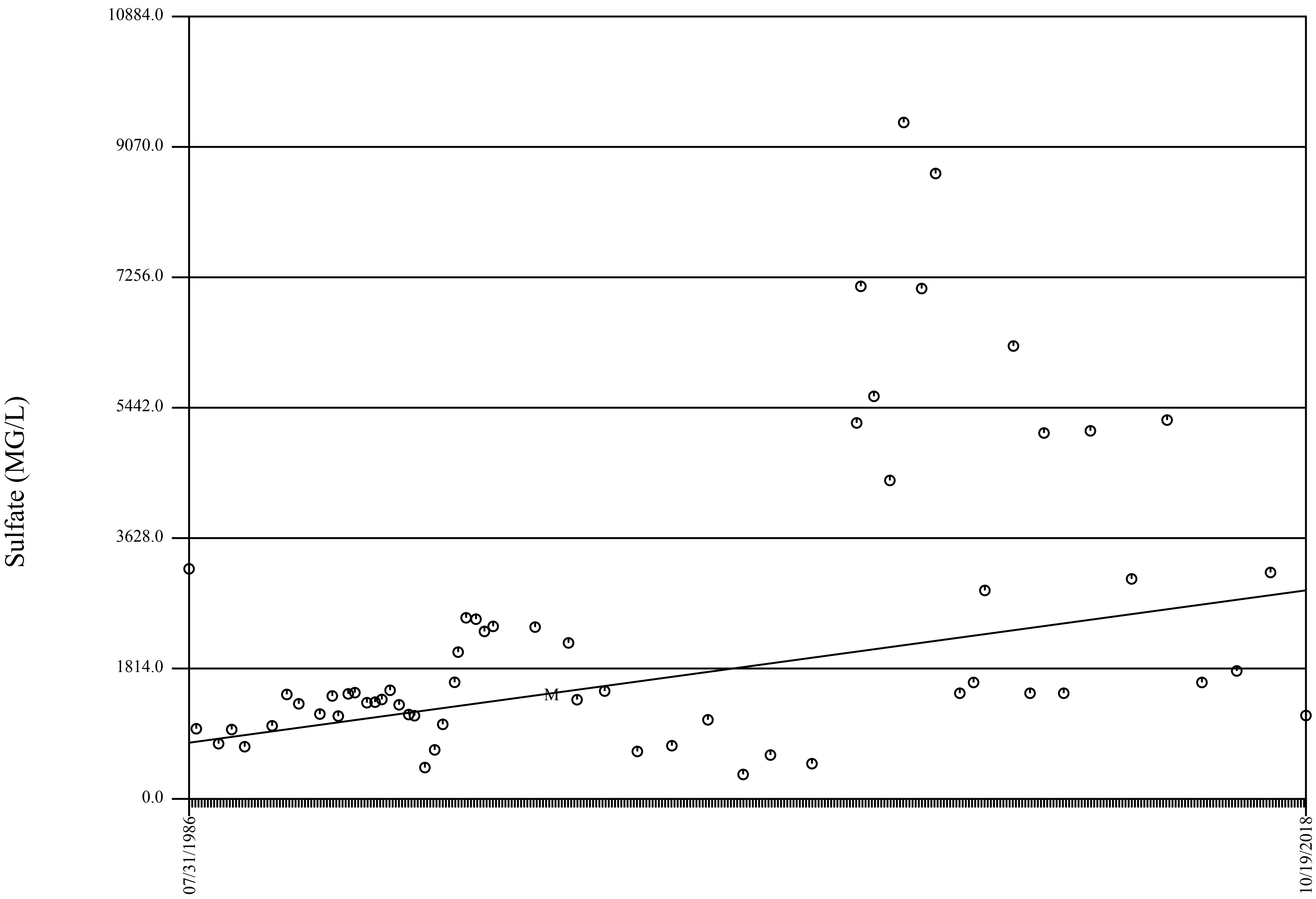
ALUV87

Solids, Dissolved (MG/L)



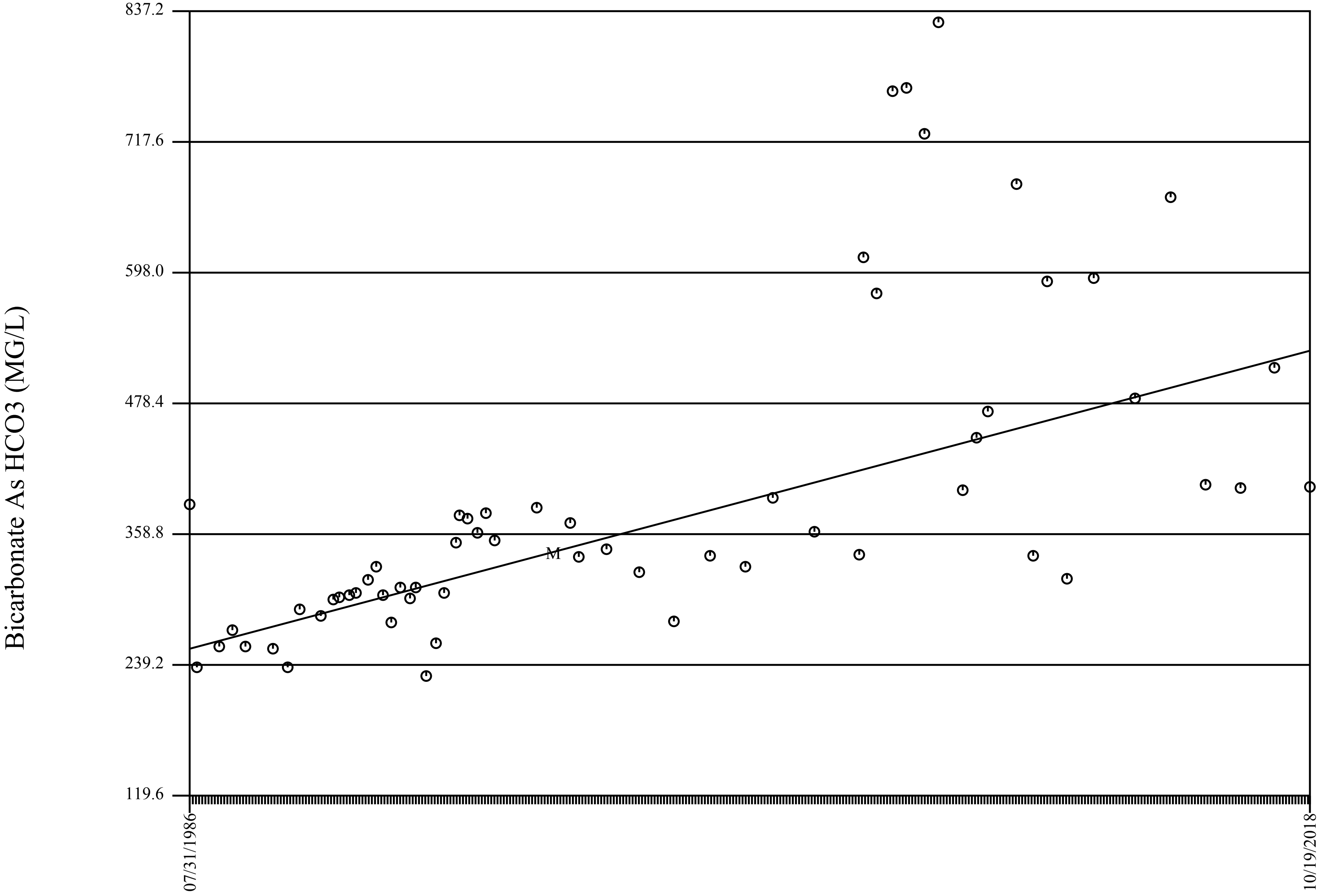
No censored data. 0.2960 Sen trend detected at 10.00% in 90.00% confidence interval 0.1240, 0.4698

ALUV87



No censored data. 0.1801 Sen trend detected at 10.00% in 90.00% confidence interval 0.0734, 0.3087

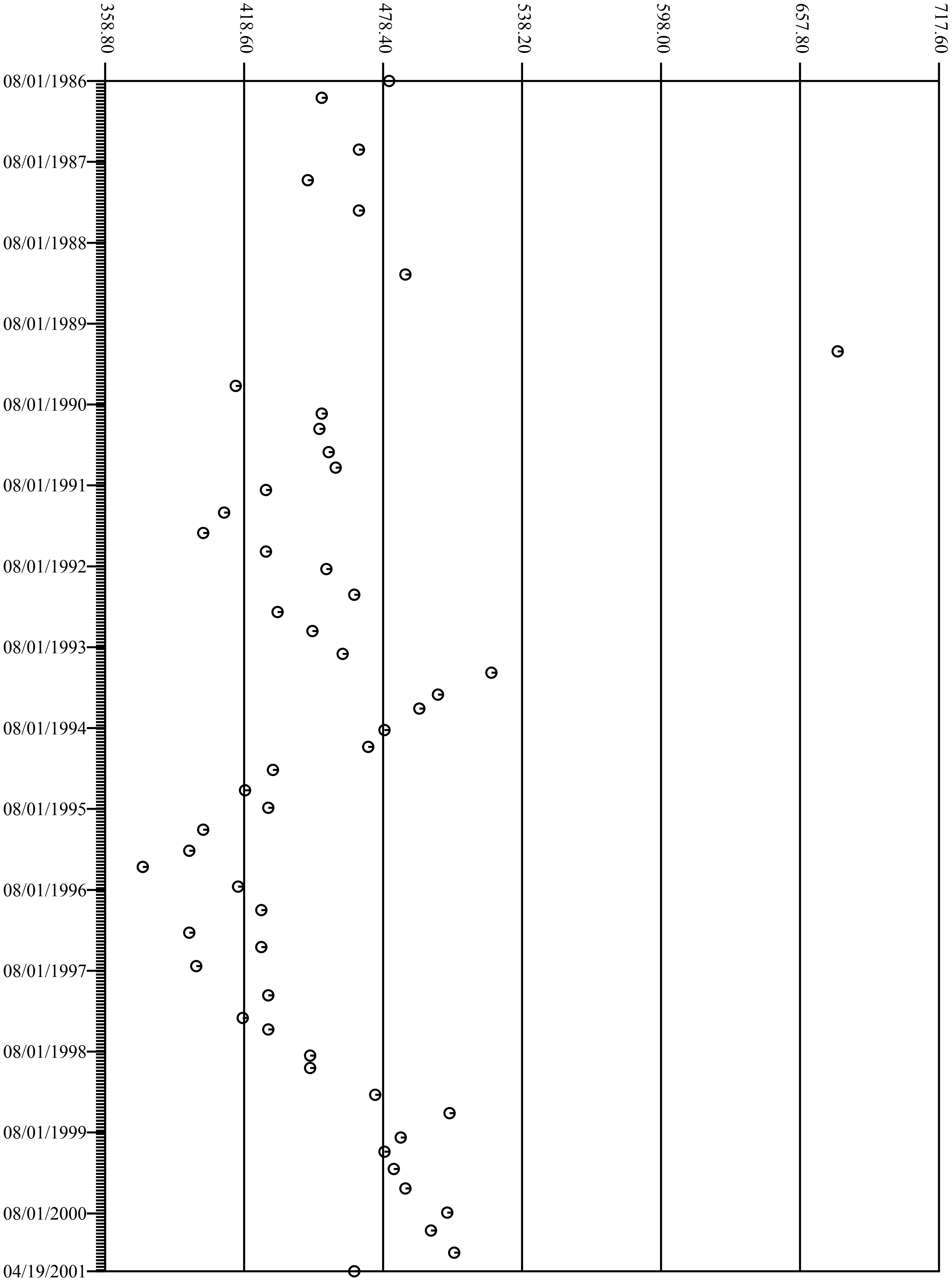
ALUV87



No censored data. 0.0232 Sen trend detected at 10.00% in 90.00% confidence interval 0.0176, 0.0308

ALUV87

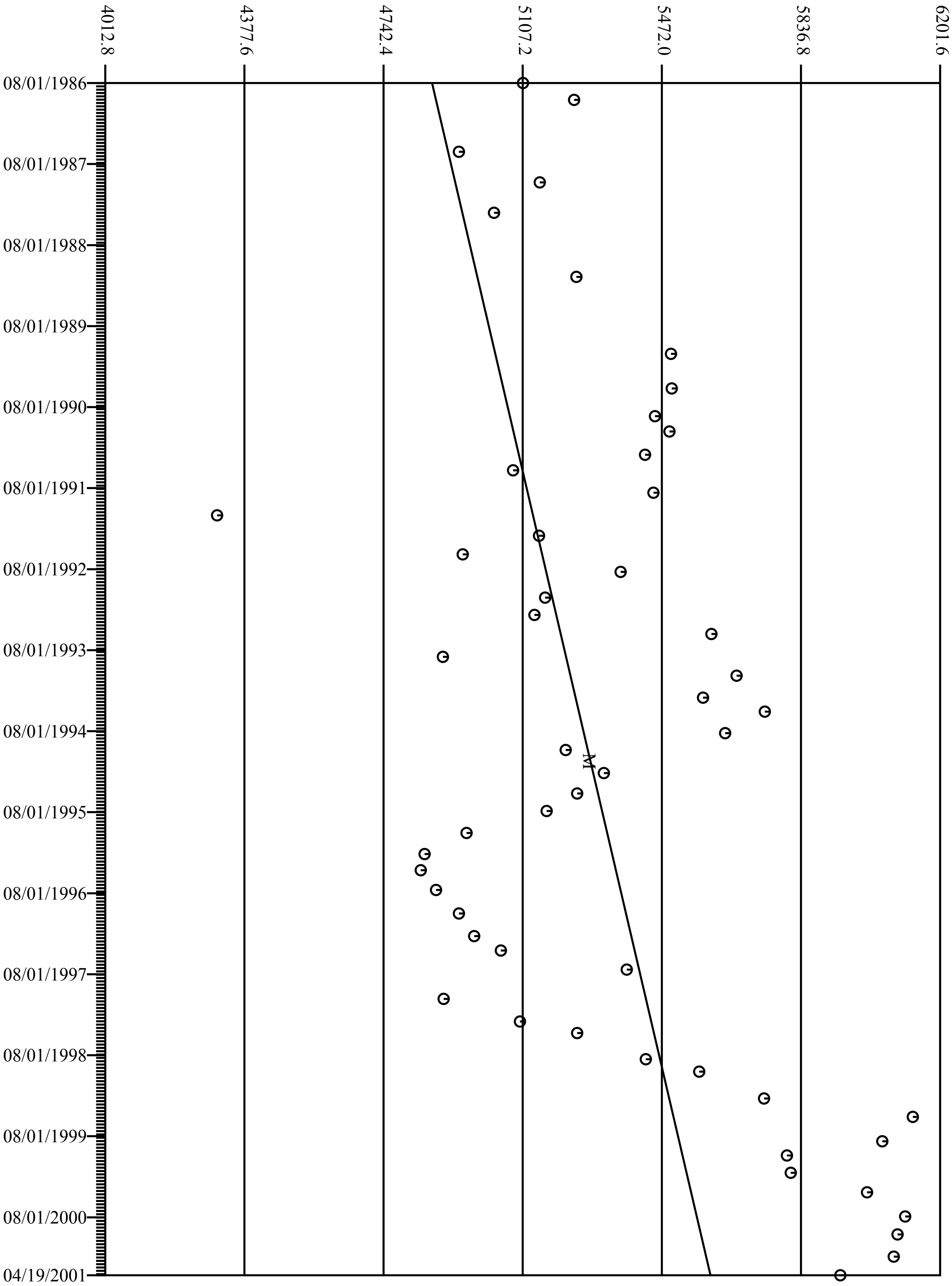
Sodium, Dissolved (MG/L)



No censored data. No trend detected at 10.00%

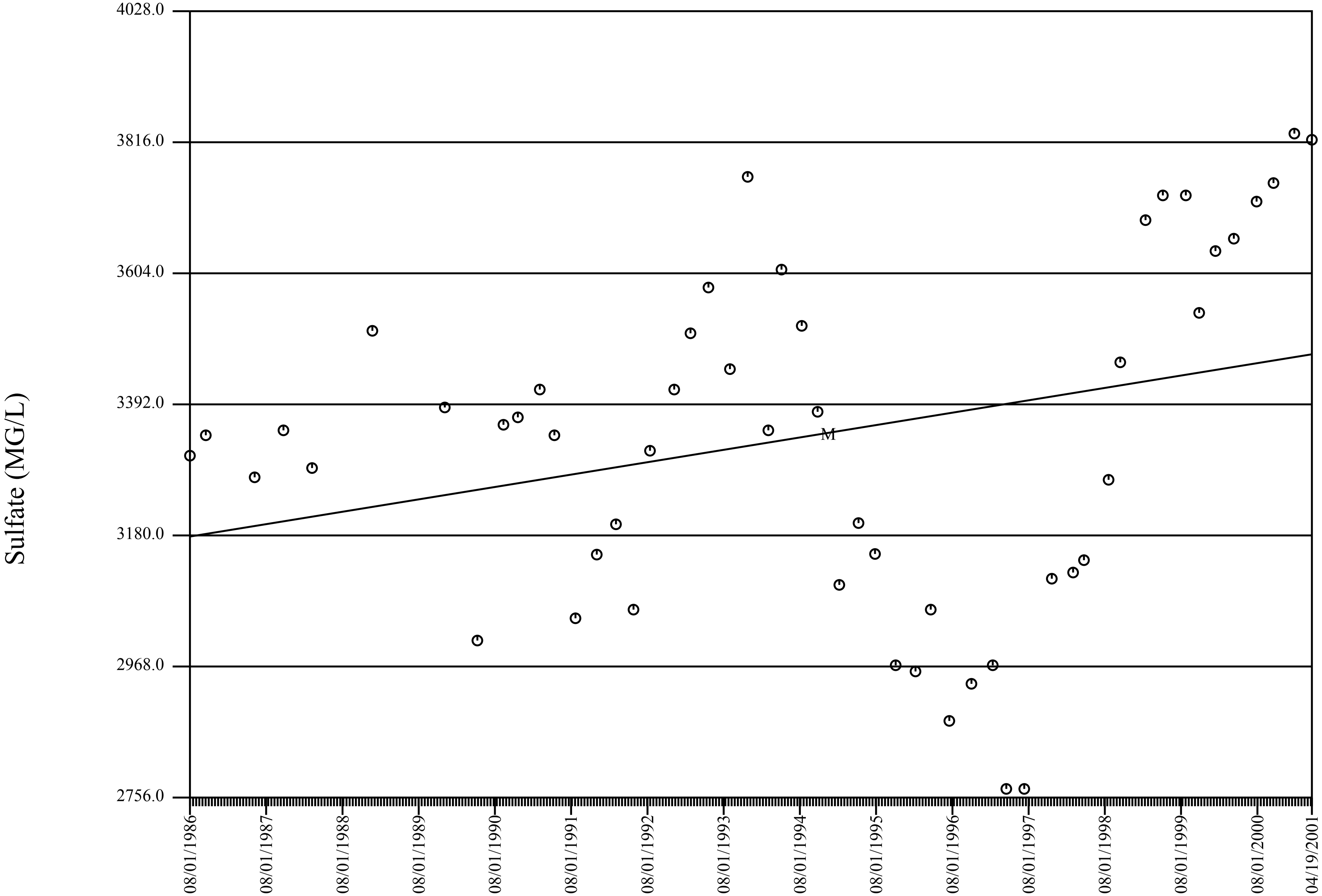
ALUV88

Solids, Dissolved (MG/L)



No censored data. 0.1358 Sen trend detected at 10.00% in 90.00% confidence interval 0.0731, 0.1842

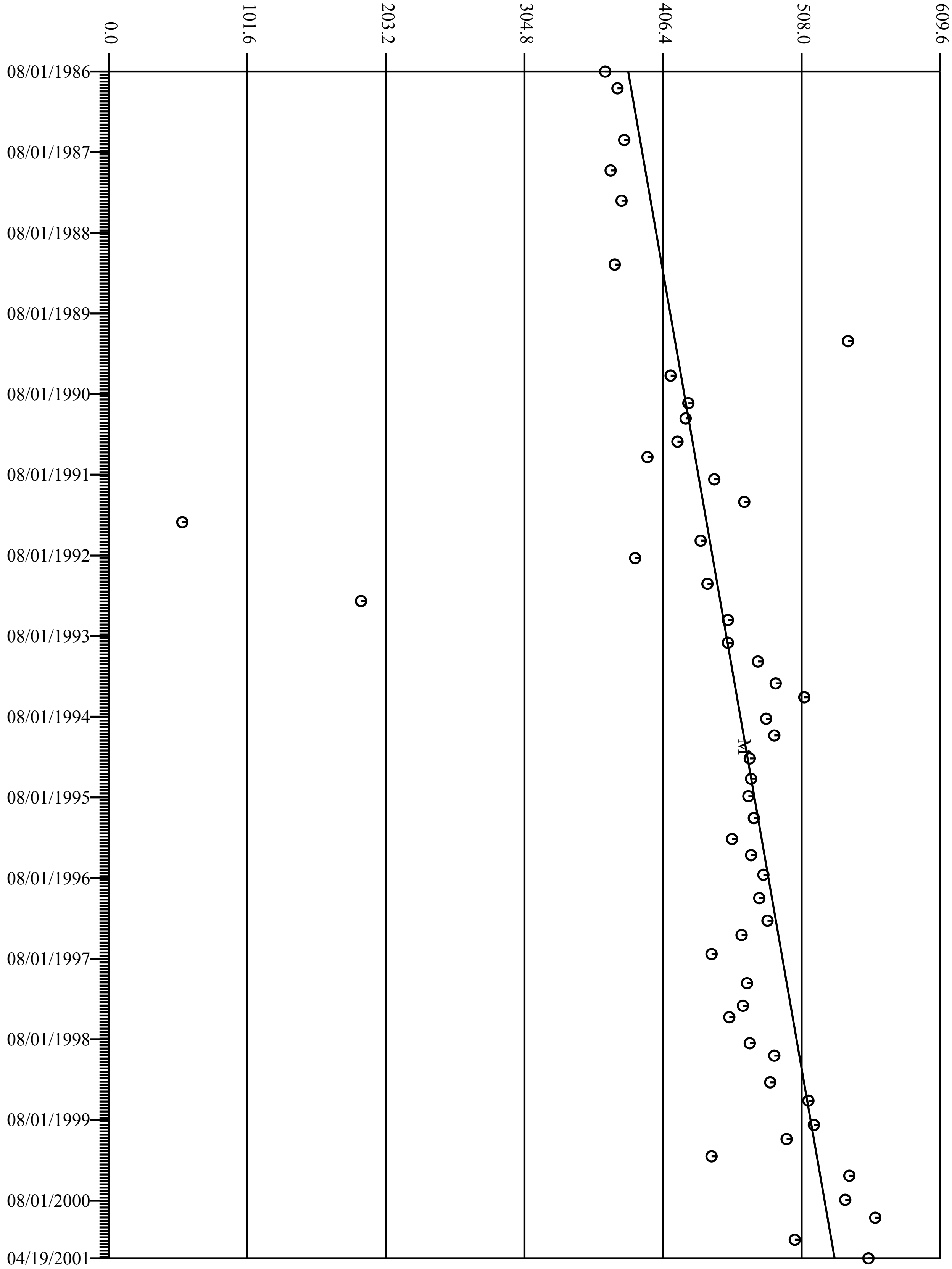
ALUV88



No censored data. 0.0548 Sen trend detected at 10.00% in 90.00% confidence interval 0.0038, 0.0903

ALUV88

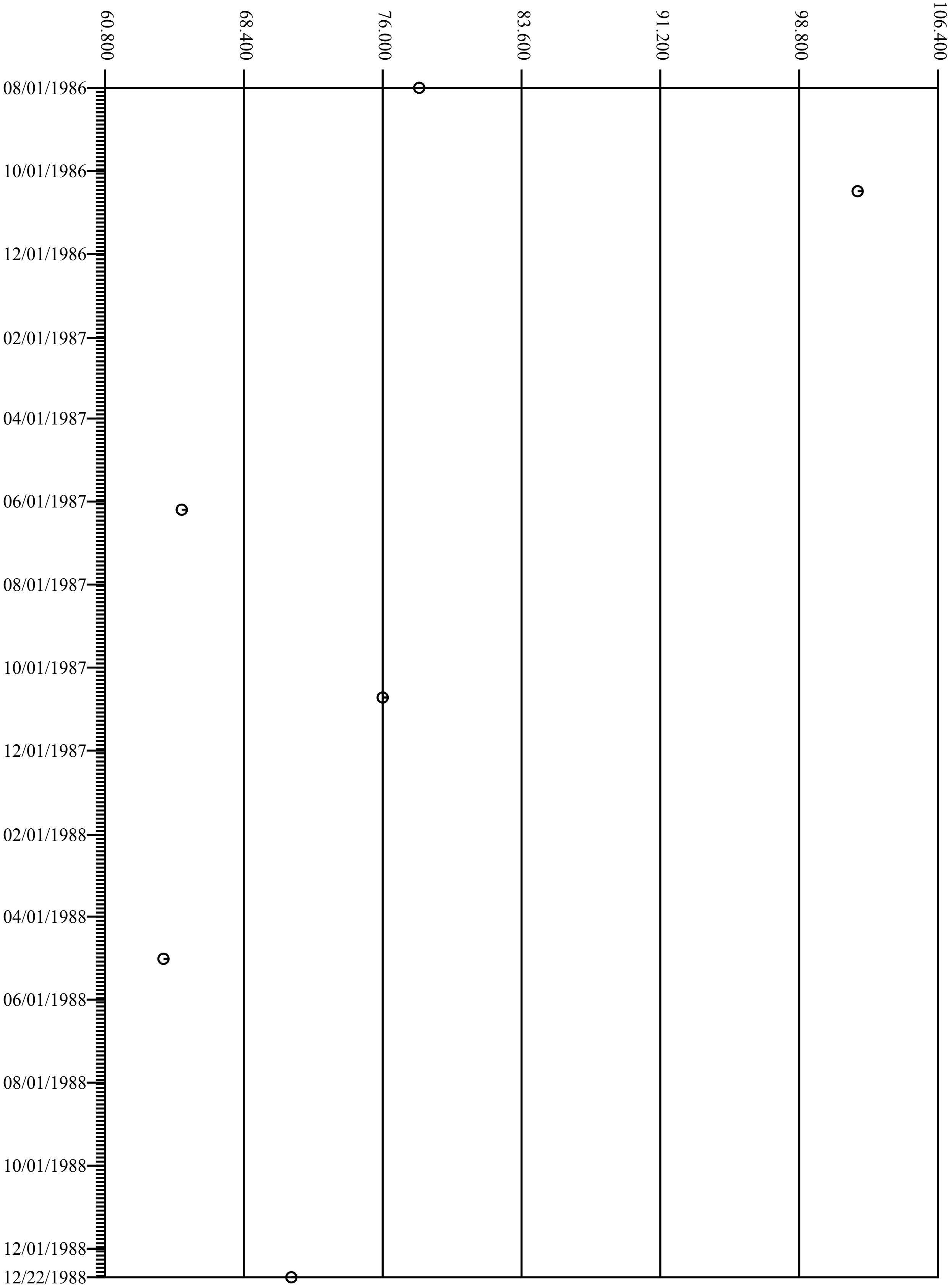
Bicarbonate As HCO3 (MG/L)



No censored data. 0.0282 Sen trend detected at 10.00% in 90.00% confidence interval 0.0227, 0.0320

ALUV88

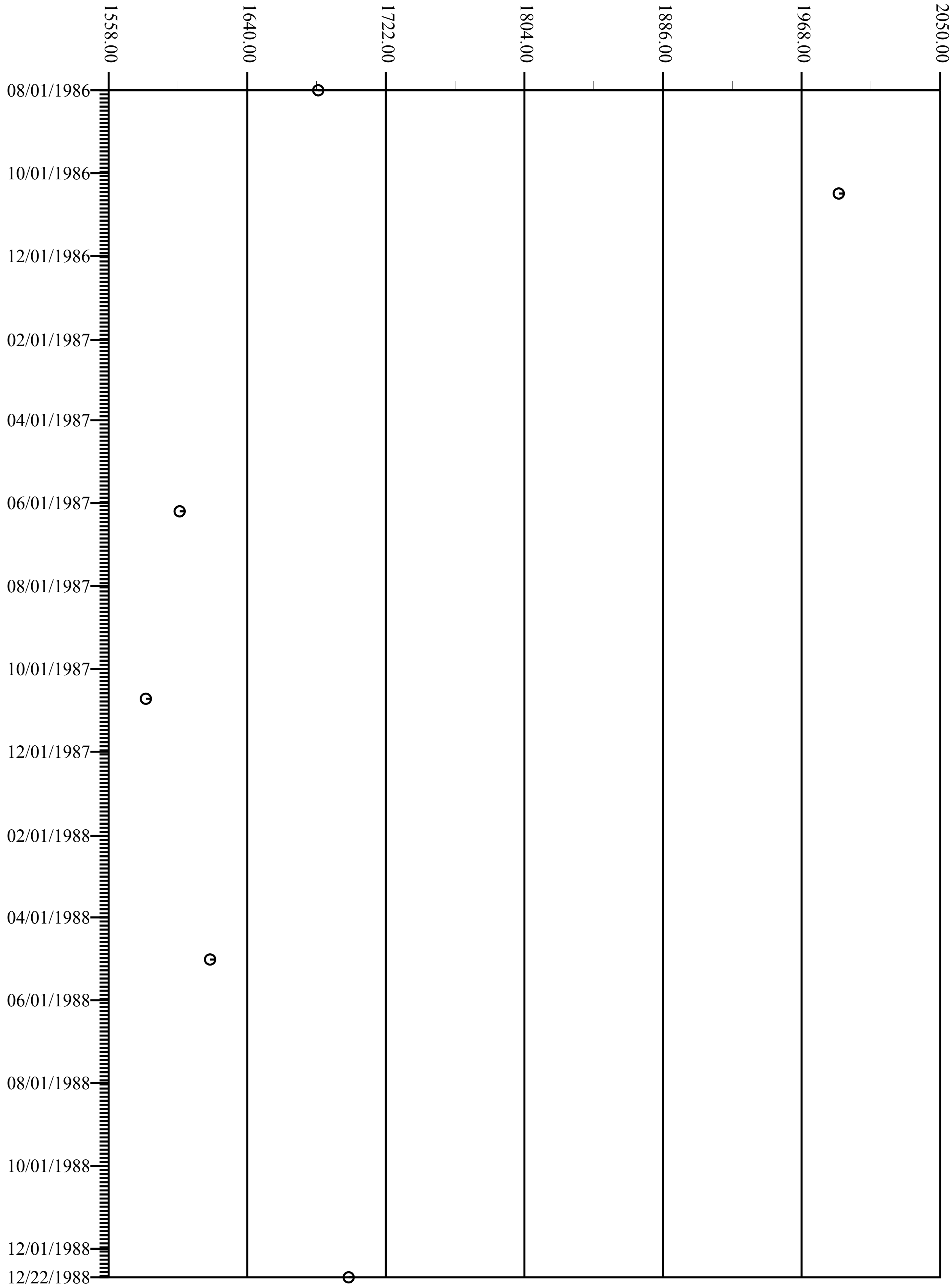
Sodium, Dissolved (MG/L)



No censored data. No trend detected at 10.00%

ALUV89

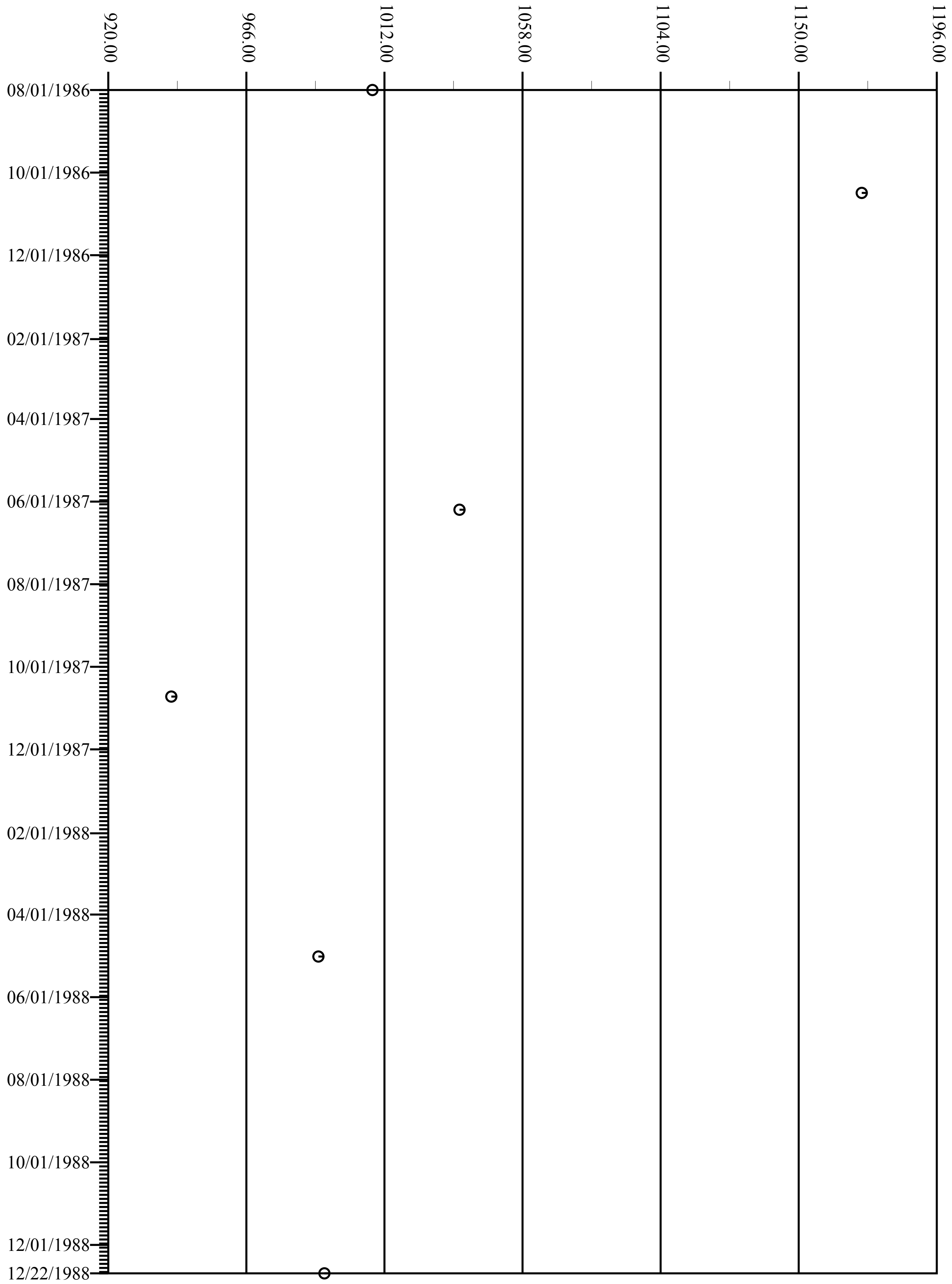
Solids, Dissolved (MG/L)



No censored data. No trend detected at 10.00%

ALUV89

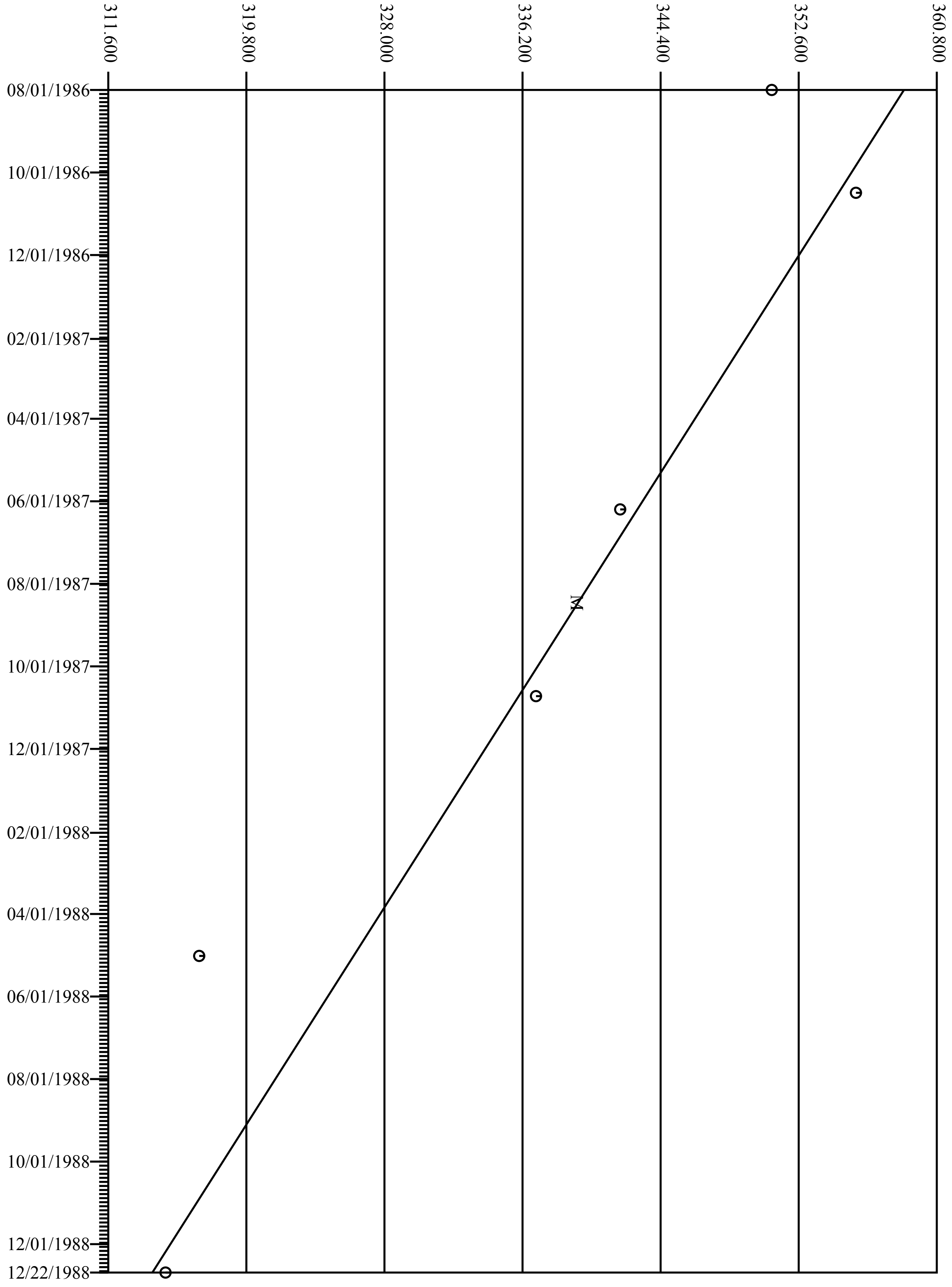
Sulfate (MG/L)



No censored data. No trend detected at 10.00%

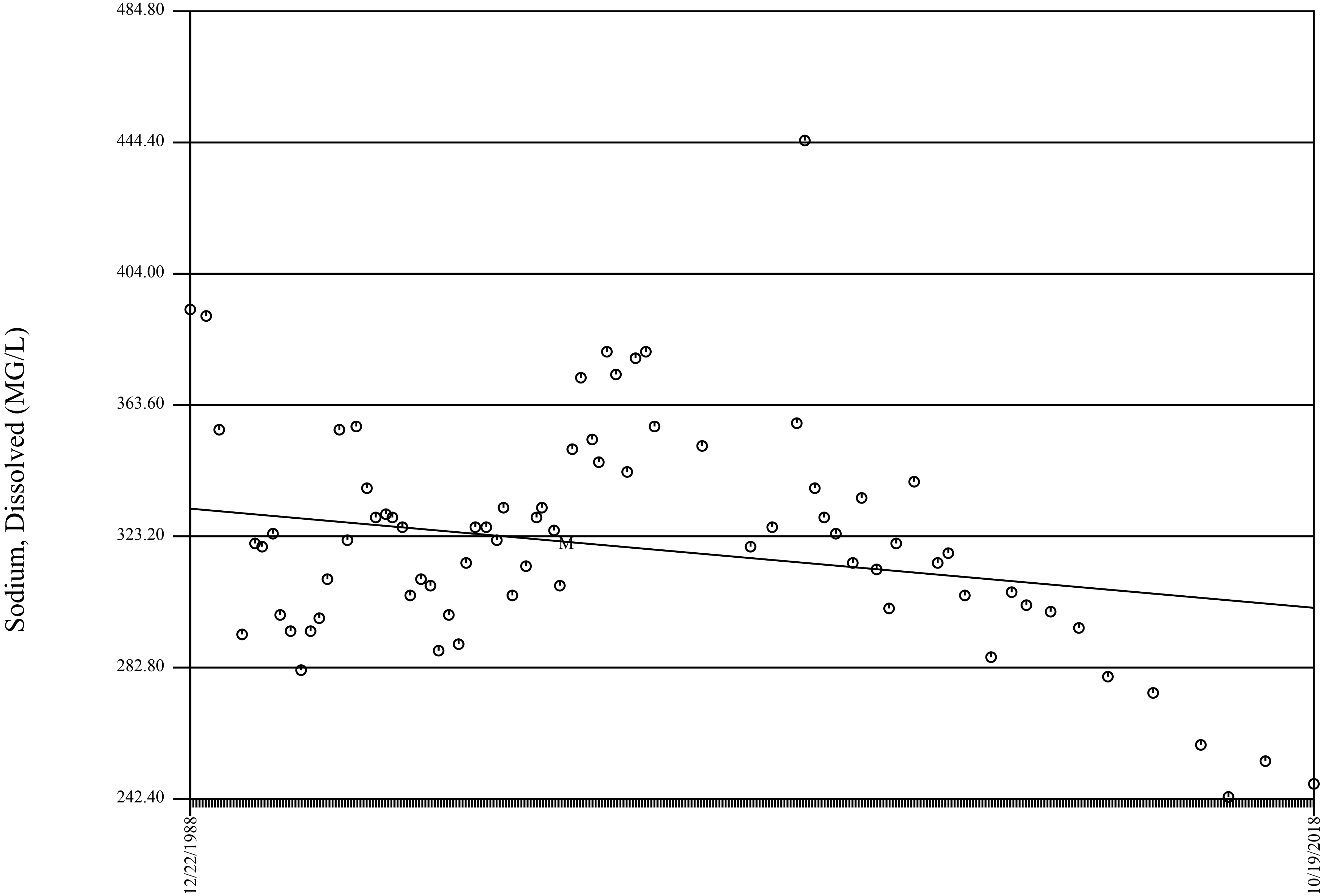
ALUV89

Bicarbonate As HCO3 (MG/L)



No censored data. -0.0511 Sen trend detected at 10.00% in 90.00% confidence interval -0.0647, -0.0301

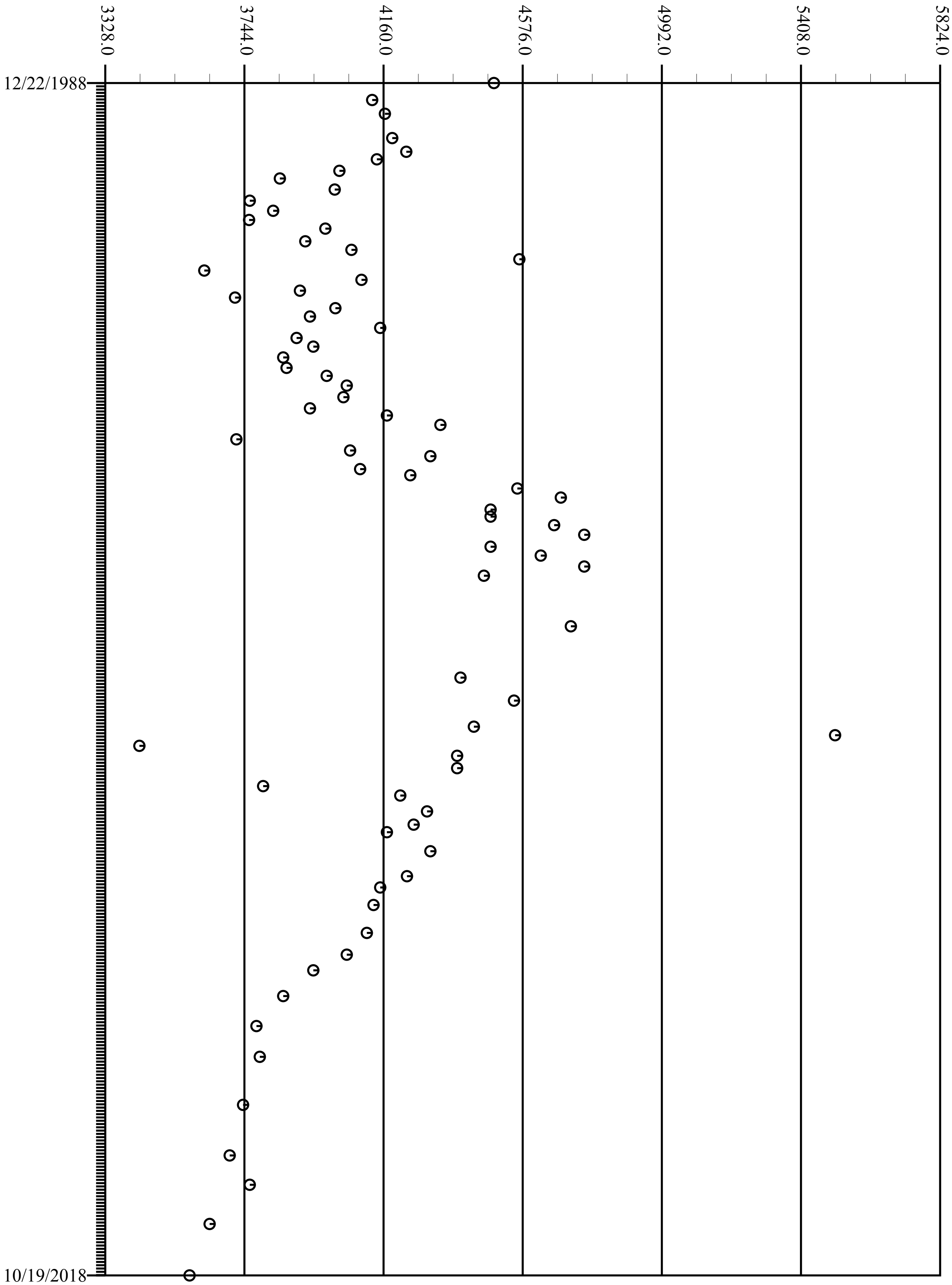
ALUV89



No censored data. -0.0028 Sen trend detected at 10.00% in 90.00% confidence interval -0.0051, -0.0004

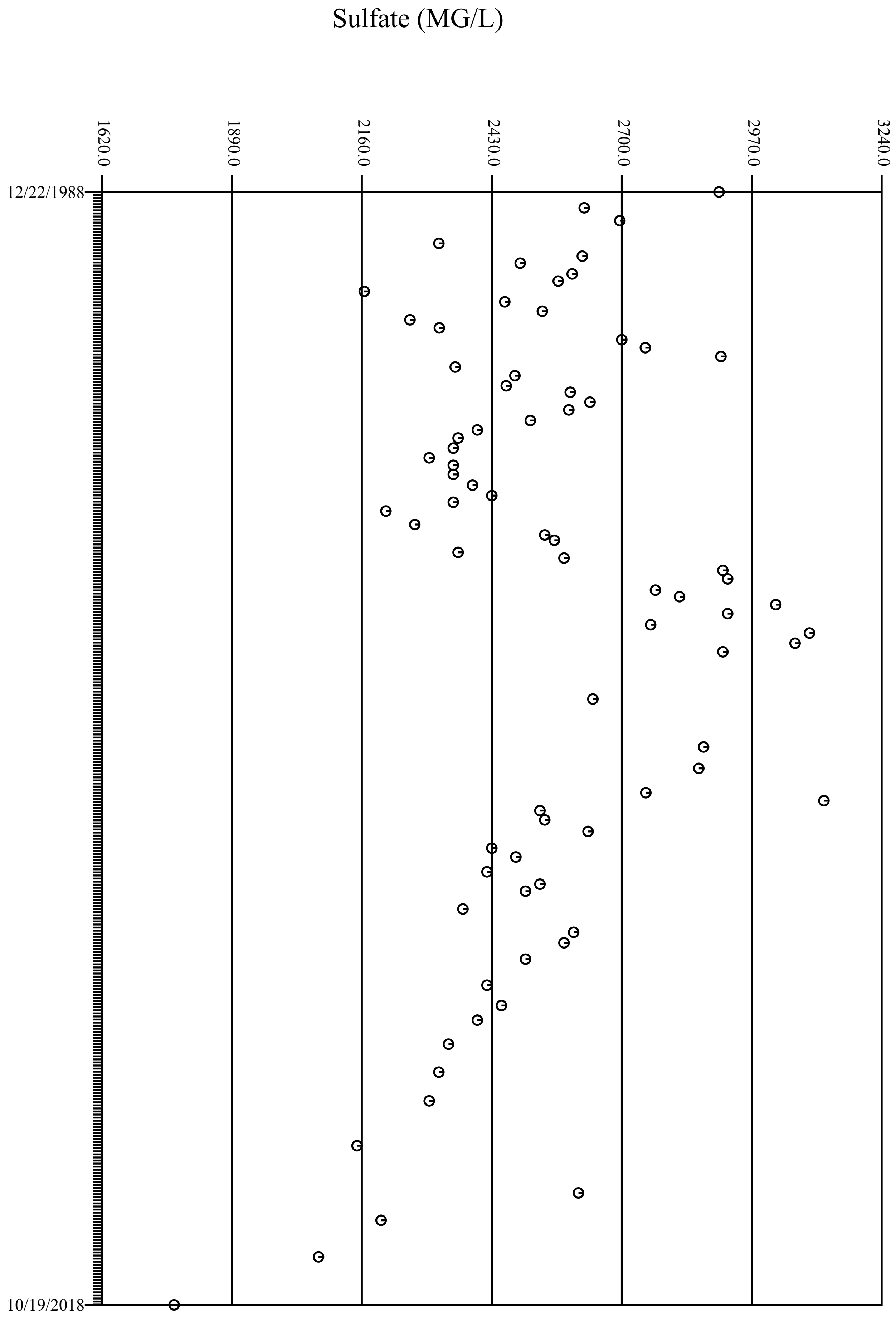
ALUV89R

Solids, Dissolved (MG/L)



No censored data. No trend detected at 10.00%

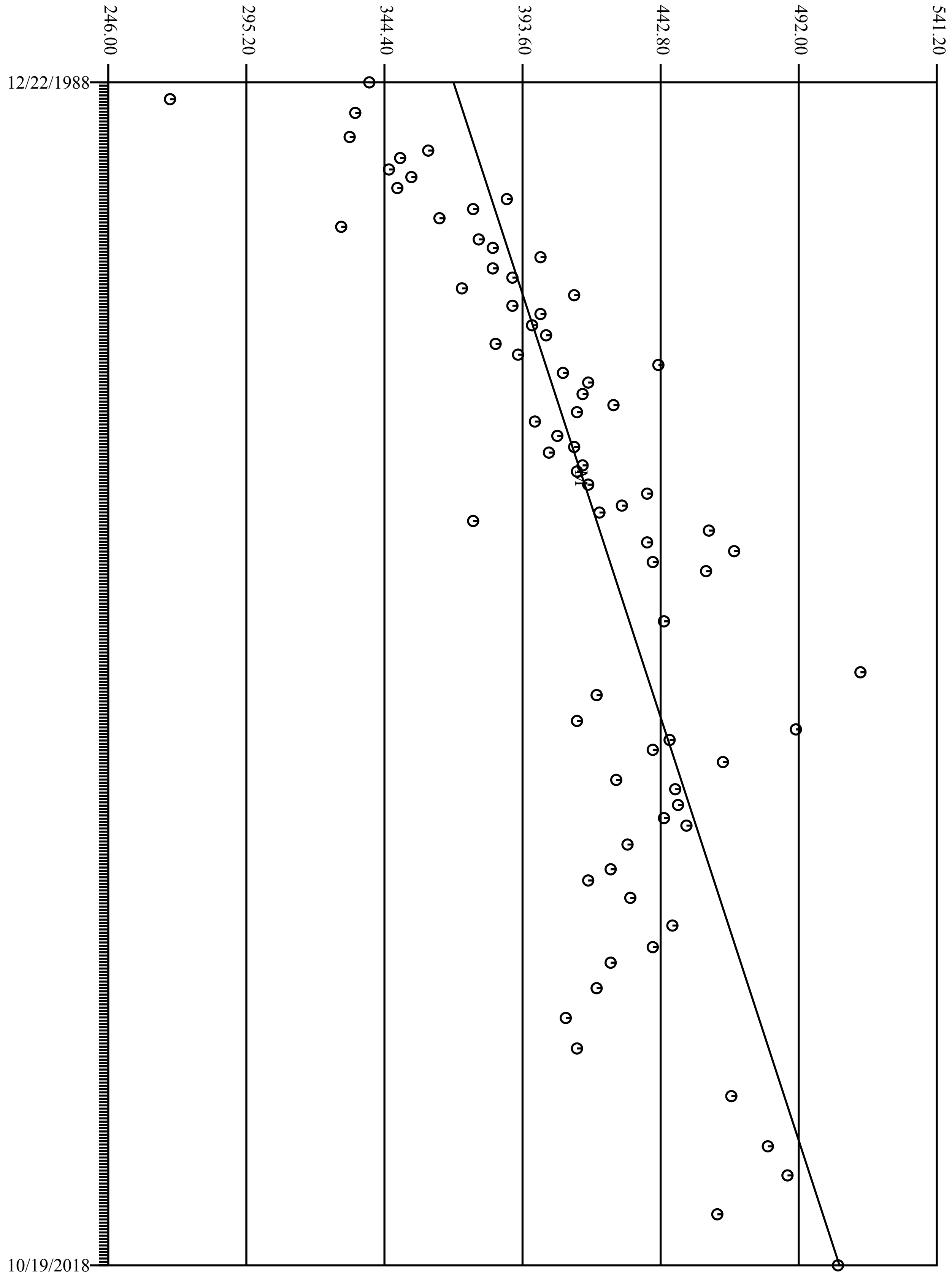
ALUV89R



No censored data. No trend detected at 10.00%

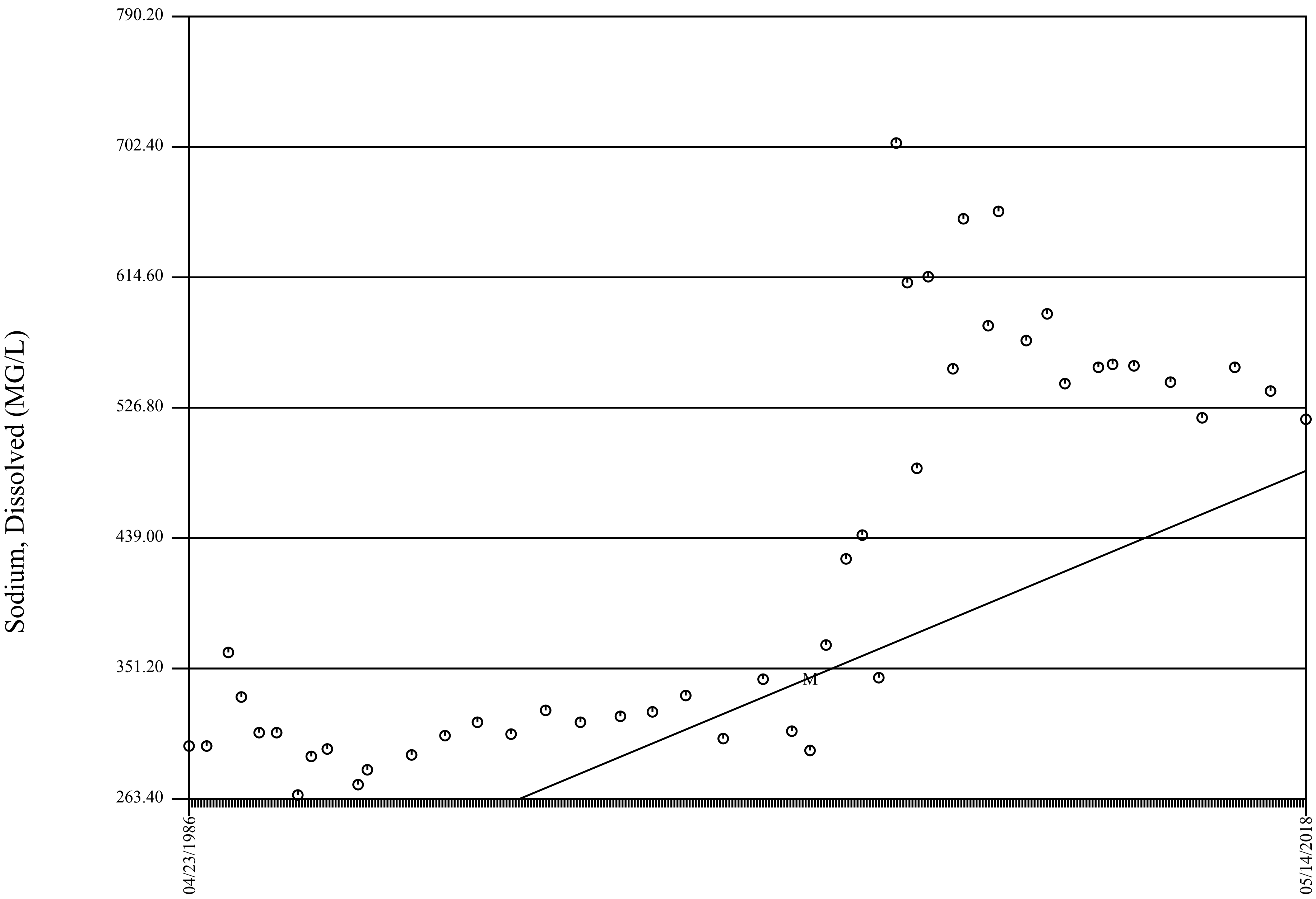
ALUV89R

Bicarbonate As HCO3 (MG/L)



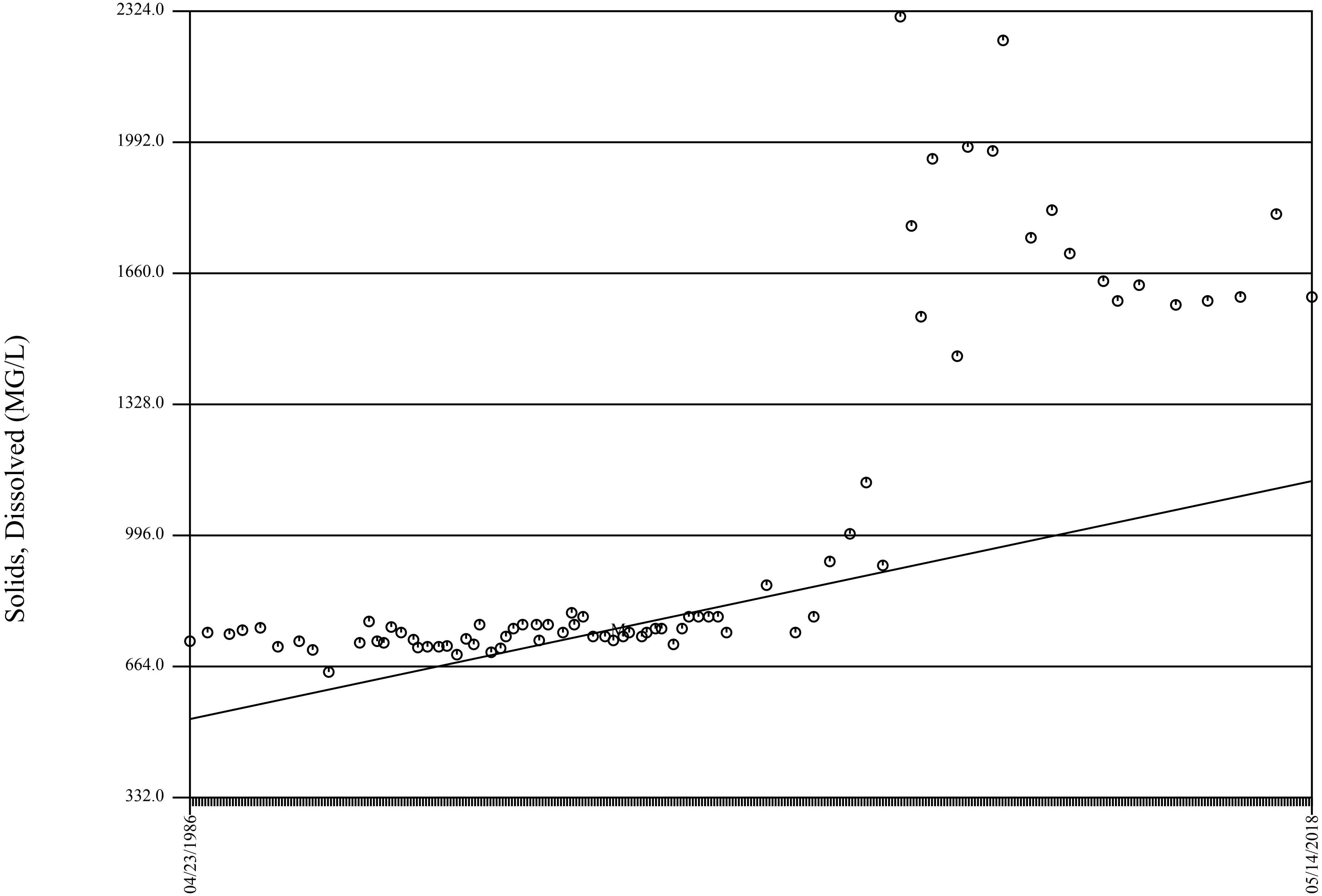
No censored data. 0.0126 Sen trend detected at 10.00% in 90.00% confidence interval 0.0108, 0.0148

ALUV89R



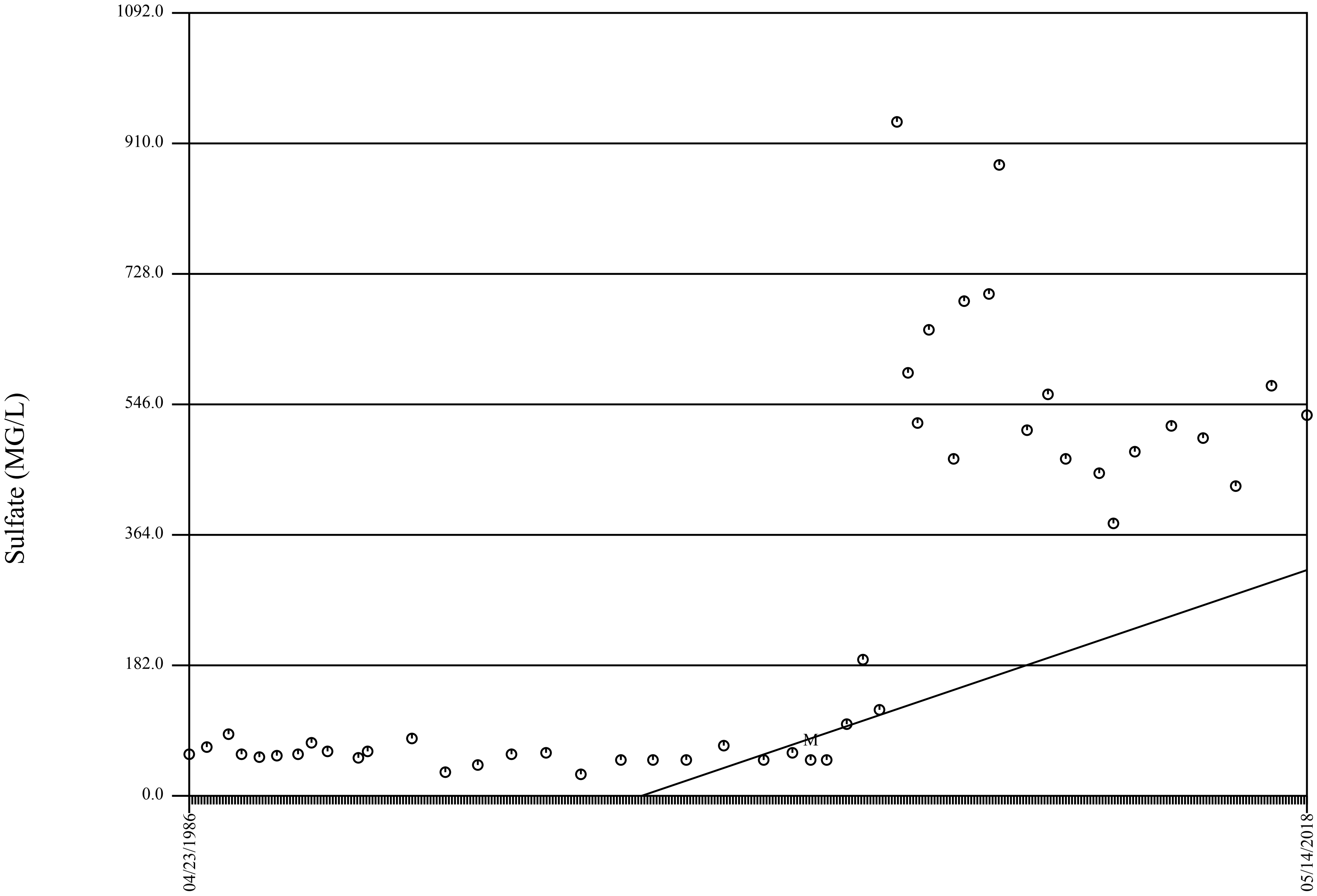
No censored data. 0.0268 Sen trend detected at 10.00% in 90.00% confidence interval 0.0195, 0.0320

WEPO40



No censored data. 0.0515 Sen trend detected at 10.00% in 90.00% confidence interval 0.0318, 0.0842

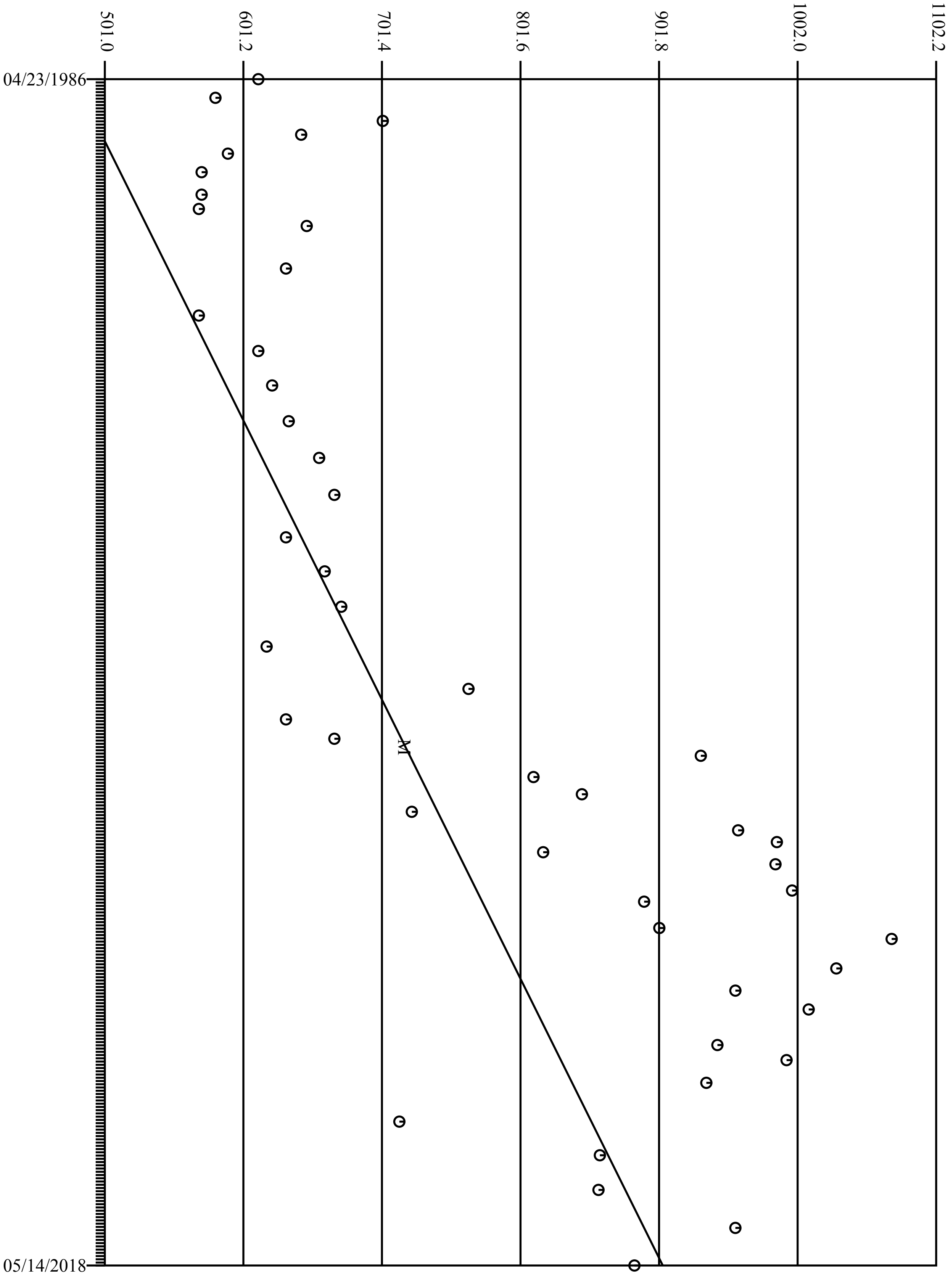
WEPO40



No censored data. 0.0452 Sen trend detected at 10.00% in 90.00% confidence interval 0.0238, 0.0577

WEPO40

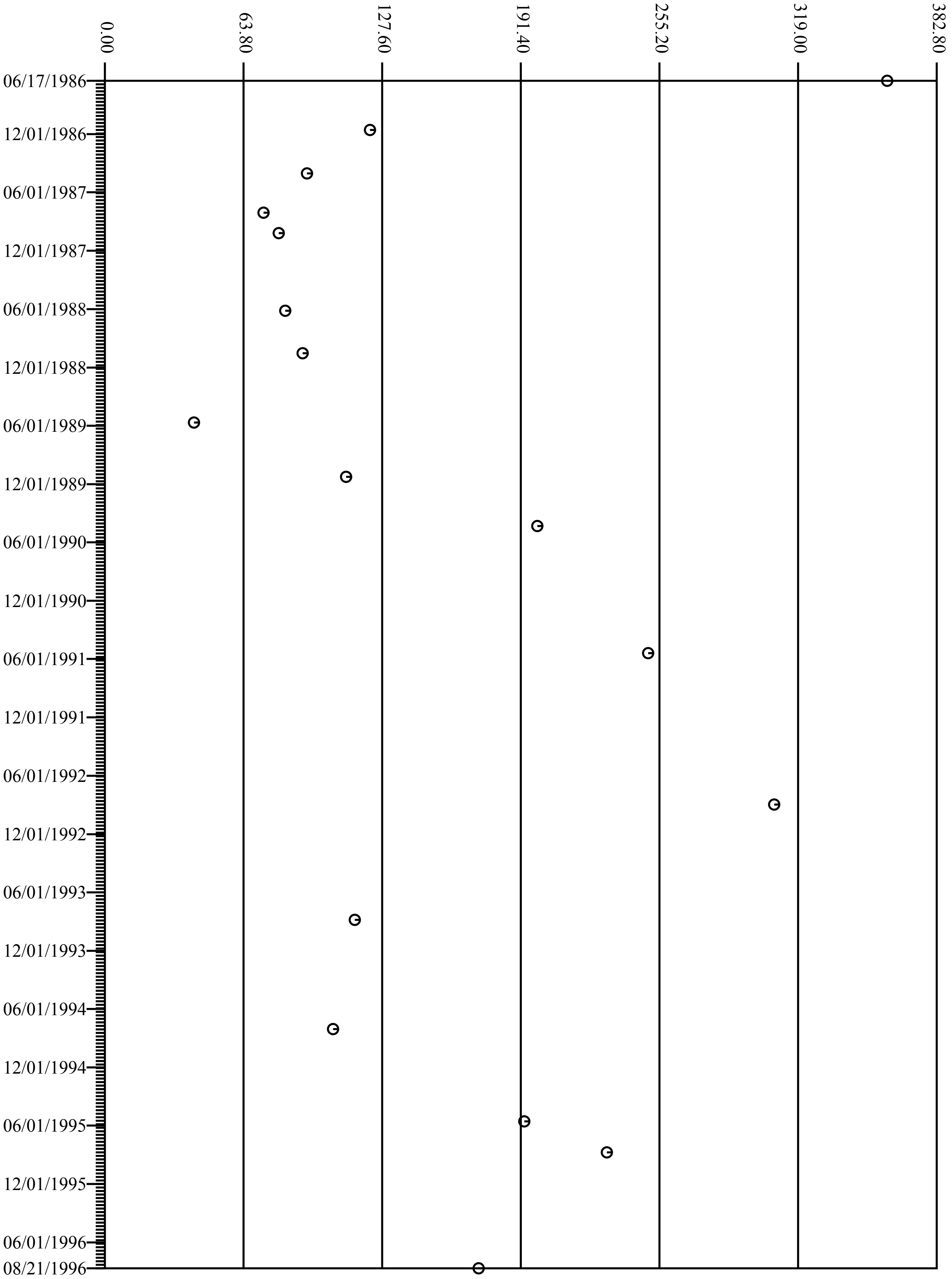
Bicarbonate As HCO3 (MG/L)



No censored data. 0.0364 Sen trend detected at 10.00% in 90.00% confidence interval 0.0292, 0.0448

WEPO40

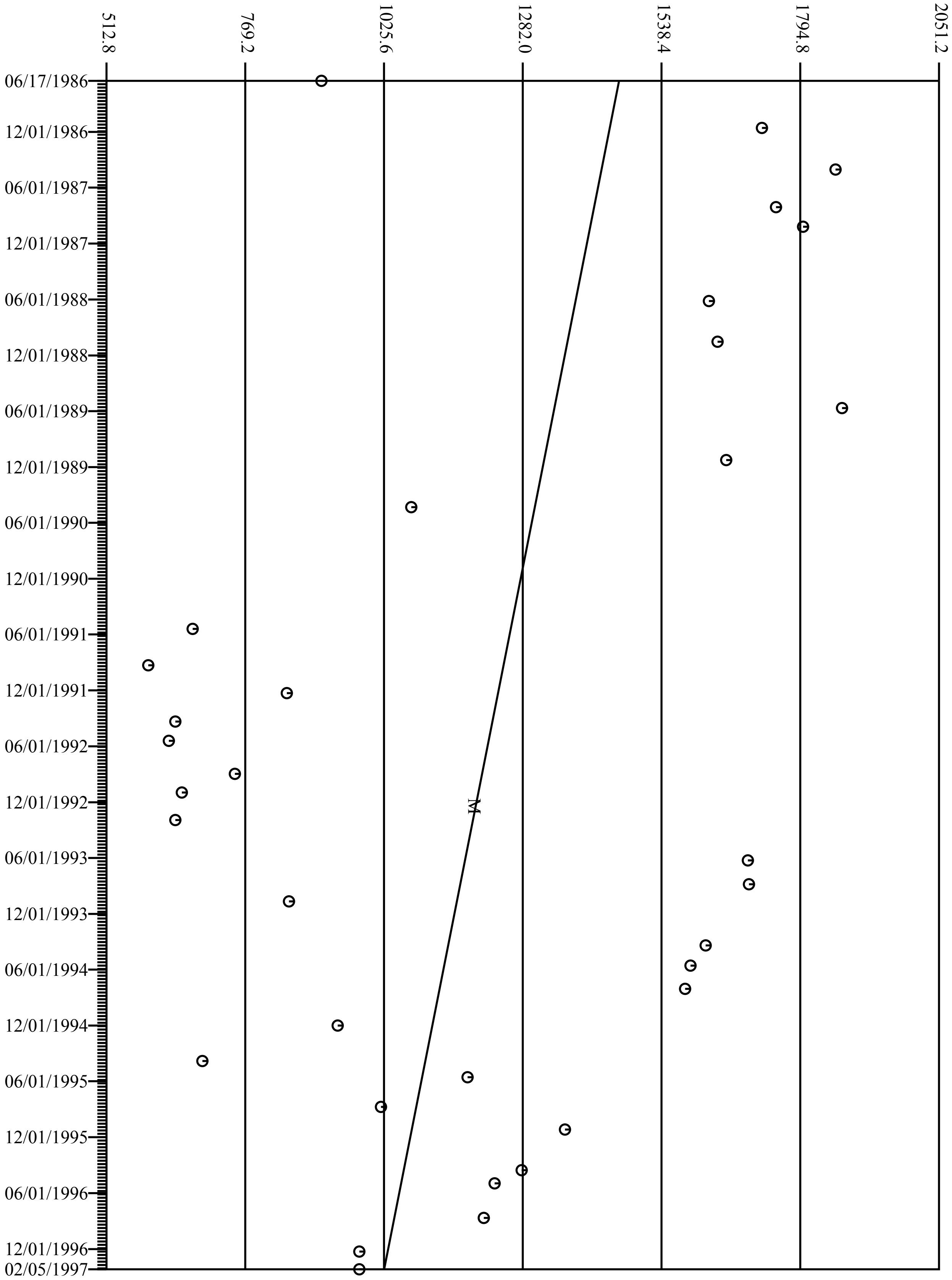
Sodium, Dissolved (MG/L)



No censored data. No trend detected at 10.00%

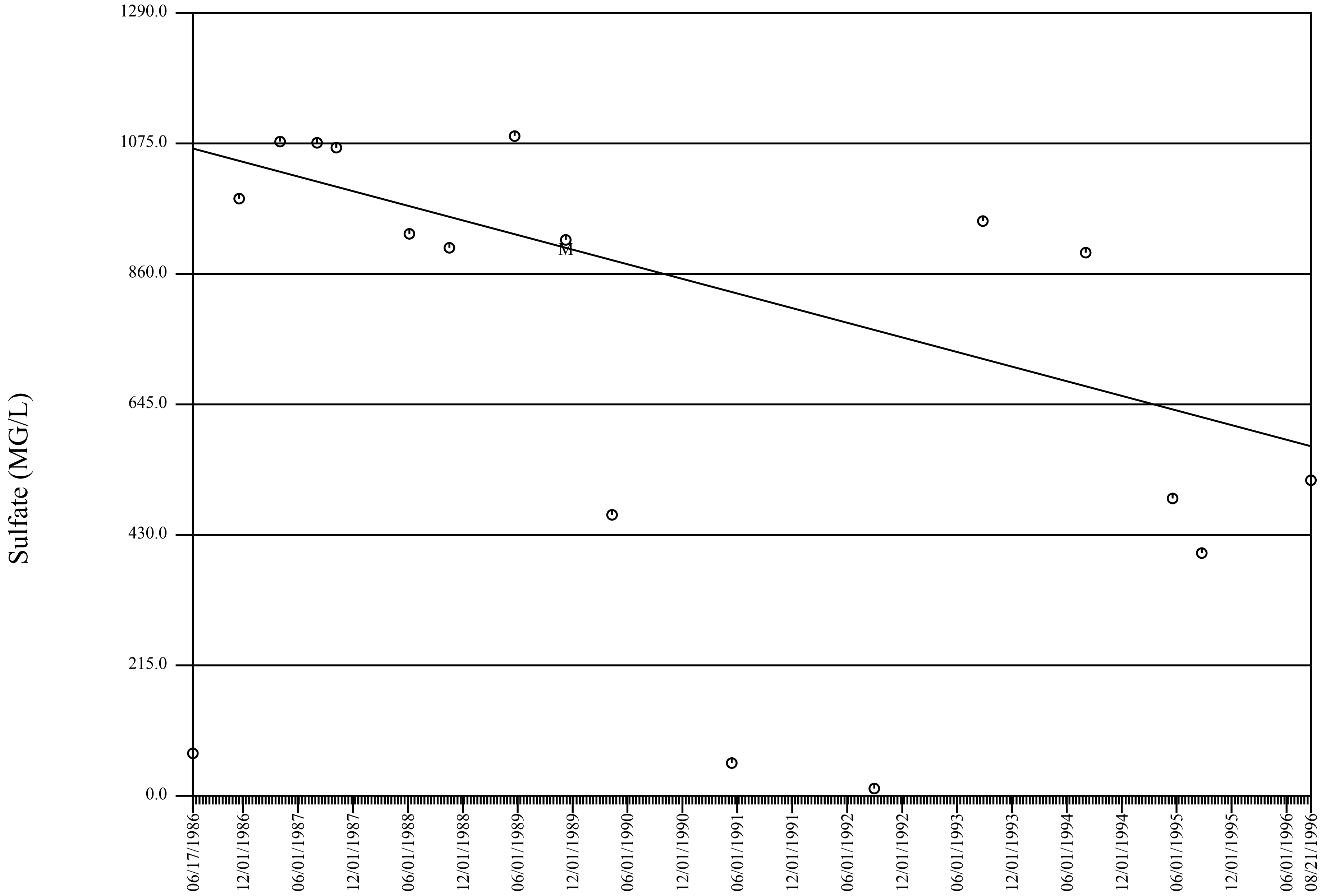
WEPO43

Solids, Dissolved (MG/L)



No censored data. -0.1117 Sen trend detected at 10.00% in 90.00% confidence interval -0.2199, 0.0153

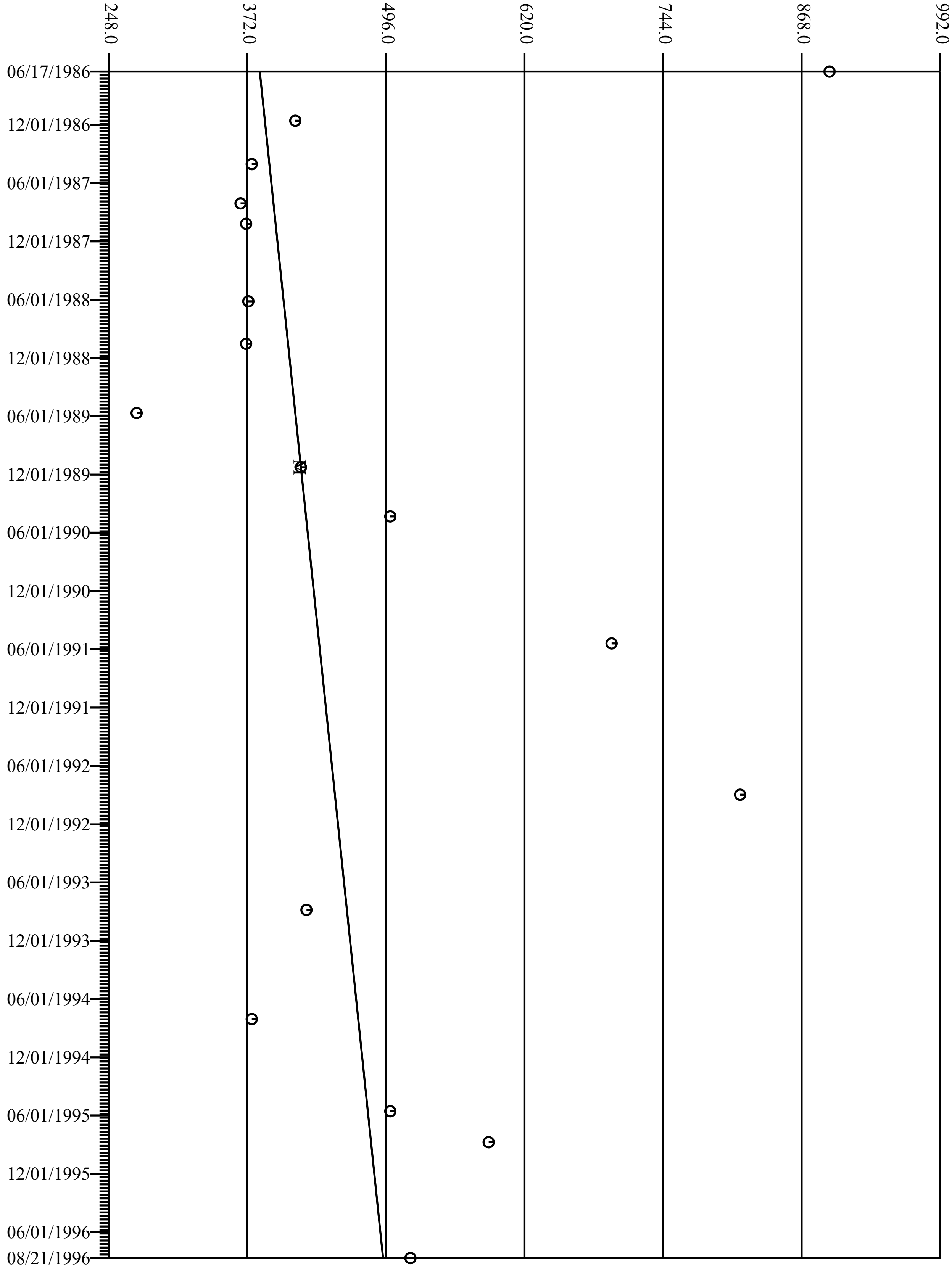
WEPO43



No censored data. -0.1319 Sen trend detected at 10.00% in 90.00% confidence interval -0.2110, -0.0150

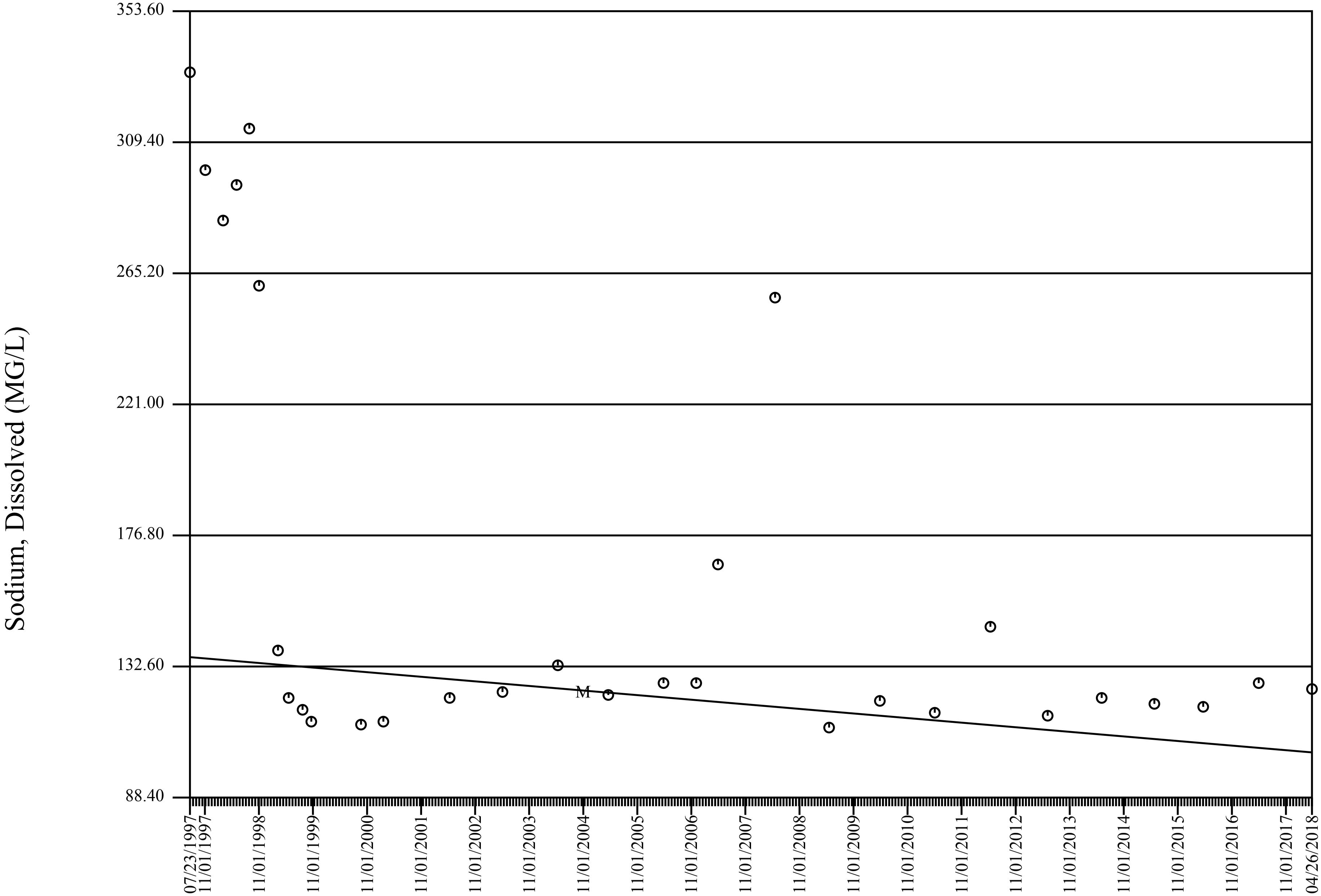
WEPO43

Bicarbonate As HCO3 (MG/L)



No censored data. 0.0297 Sen trend detected at 10.00% in 90.00% confidence interval -0.0064, 0.0683

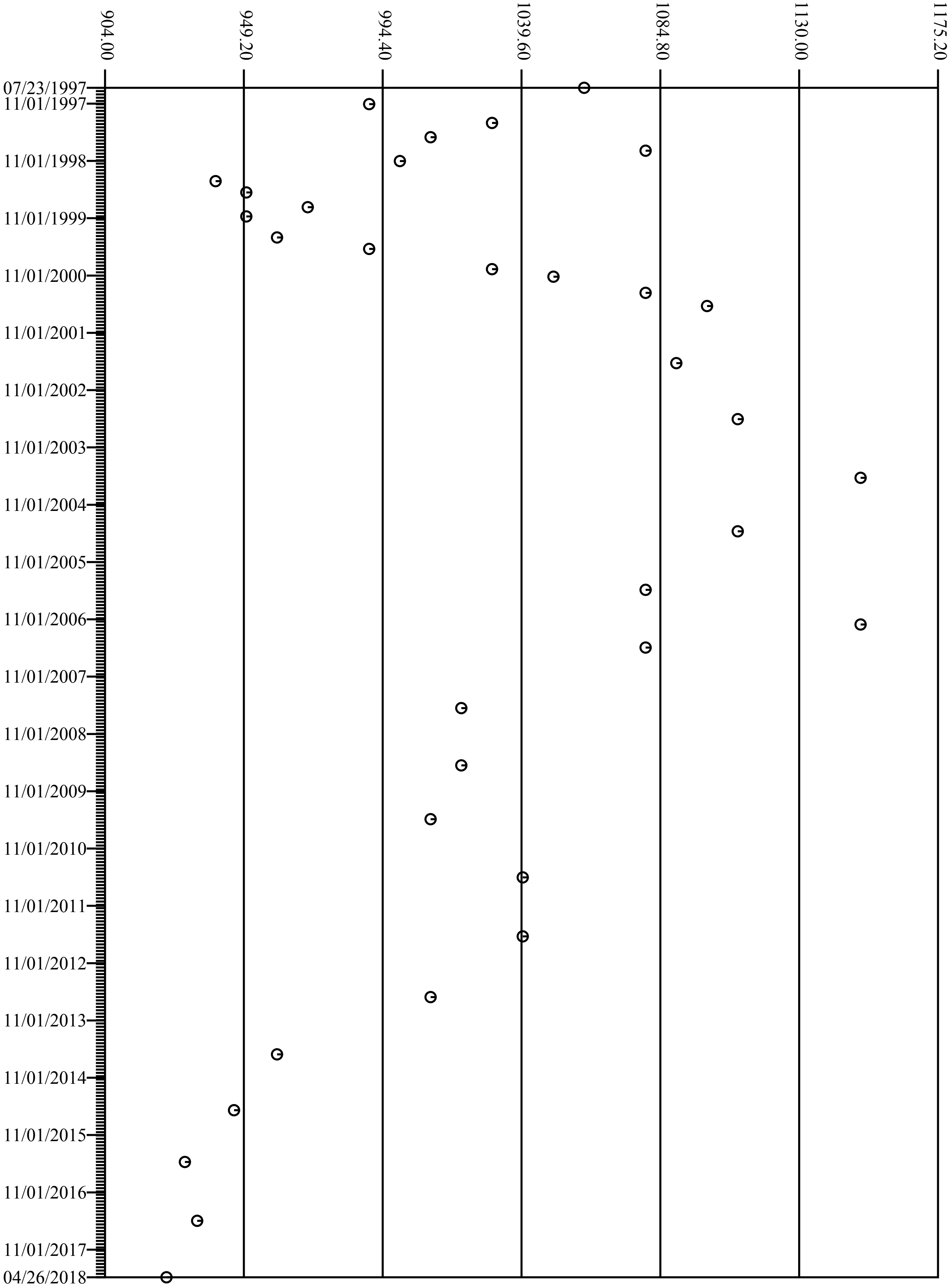
WEPO43



No censored data. -0.0042 Sen trend detected at 10.00% in 90.00% confidence interval -0.0223, -0.0006

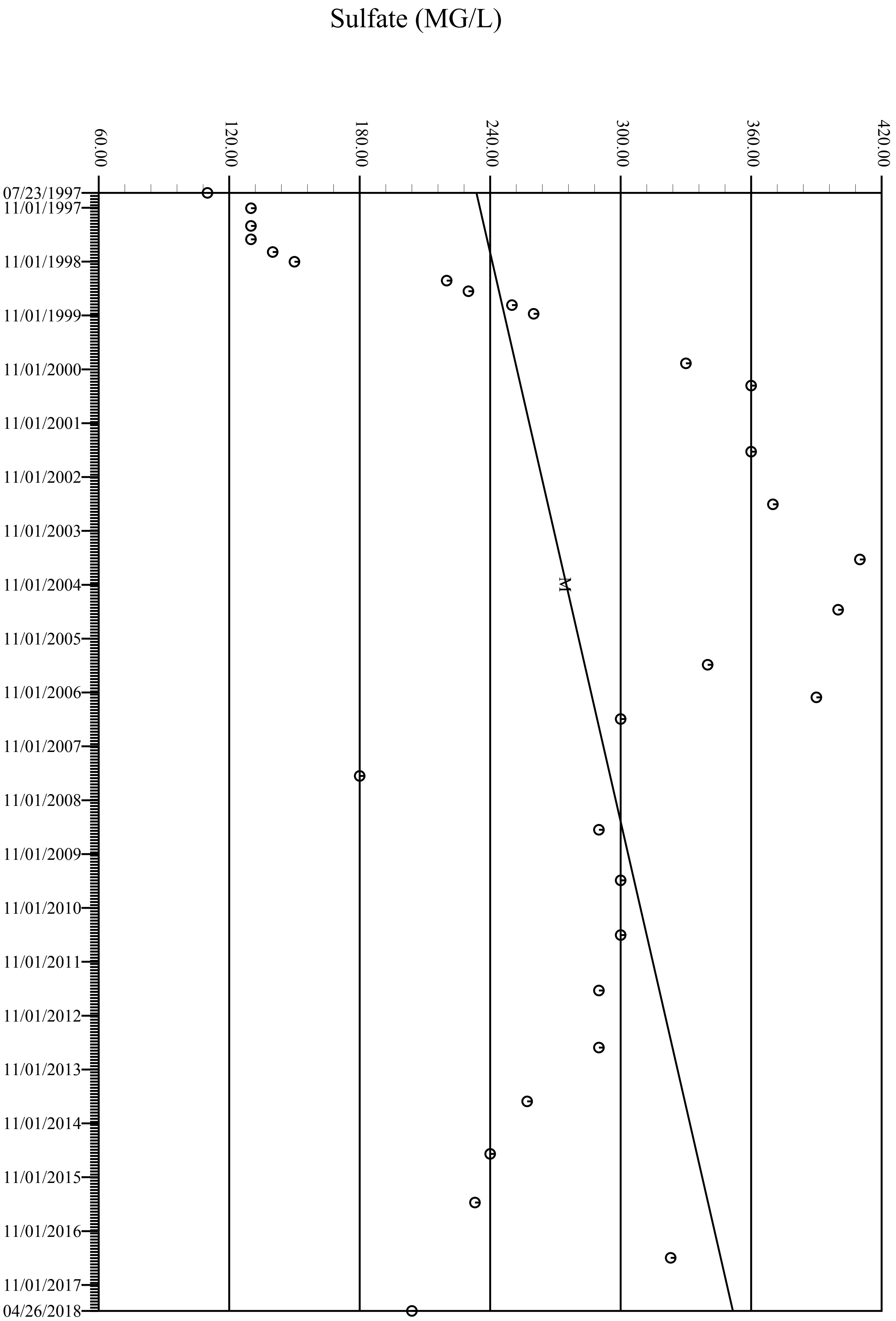
WEPO43R

Solids, Dissolved (MG/L)



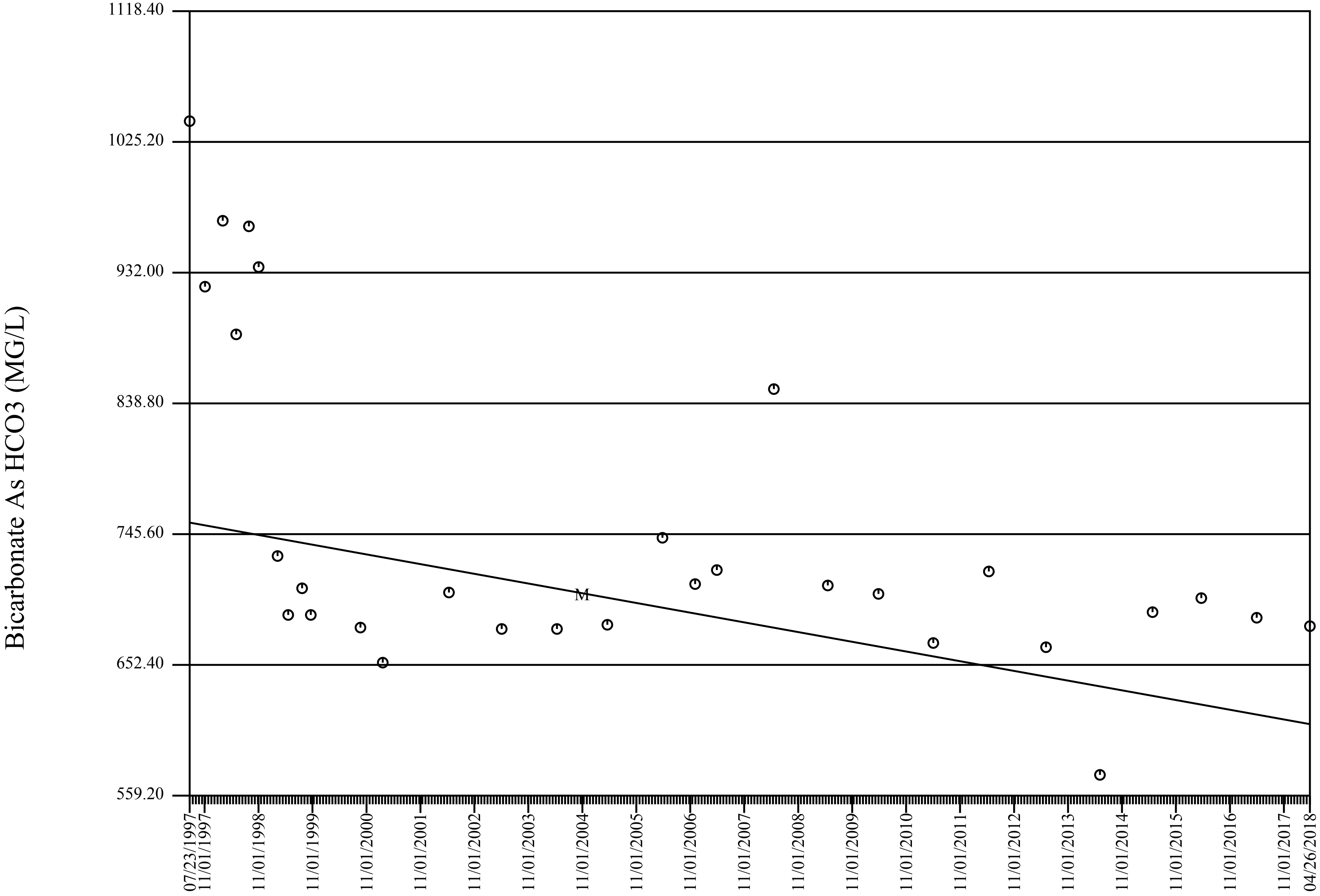
No censored data. No trend detected at 10.00%

WEPO43R



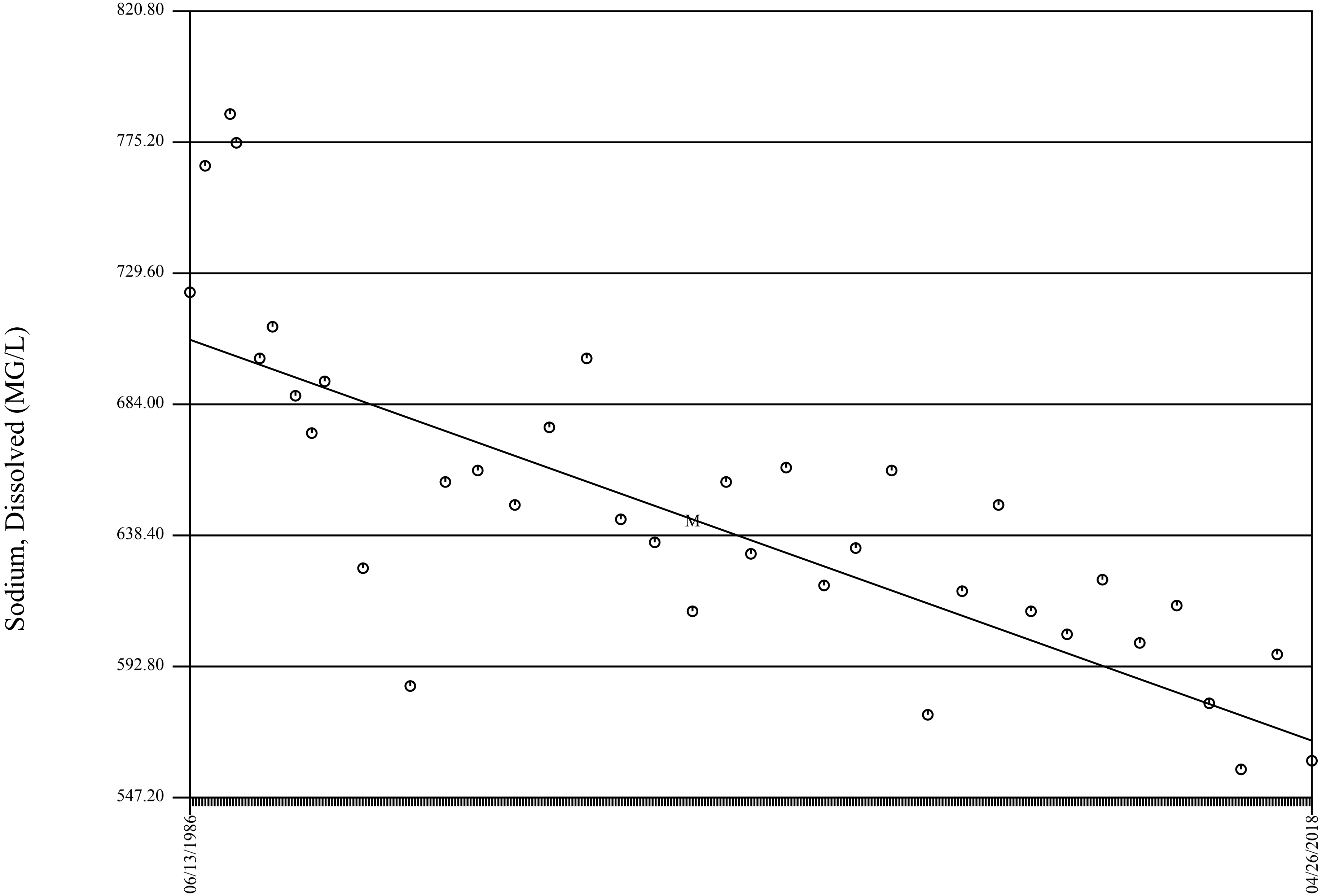
No censored data. 0.0156 Sen trend detected at 10.00% in 90.00% confidence interval 0.0041, 0.0305

WEPO43R



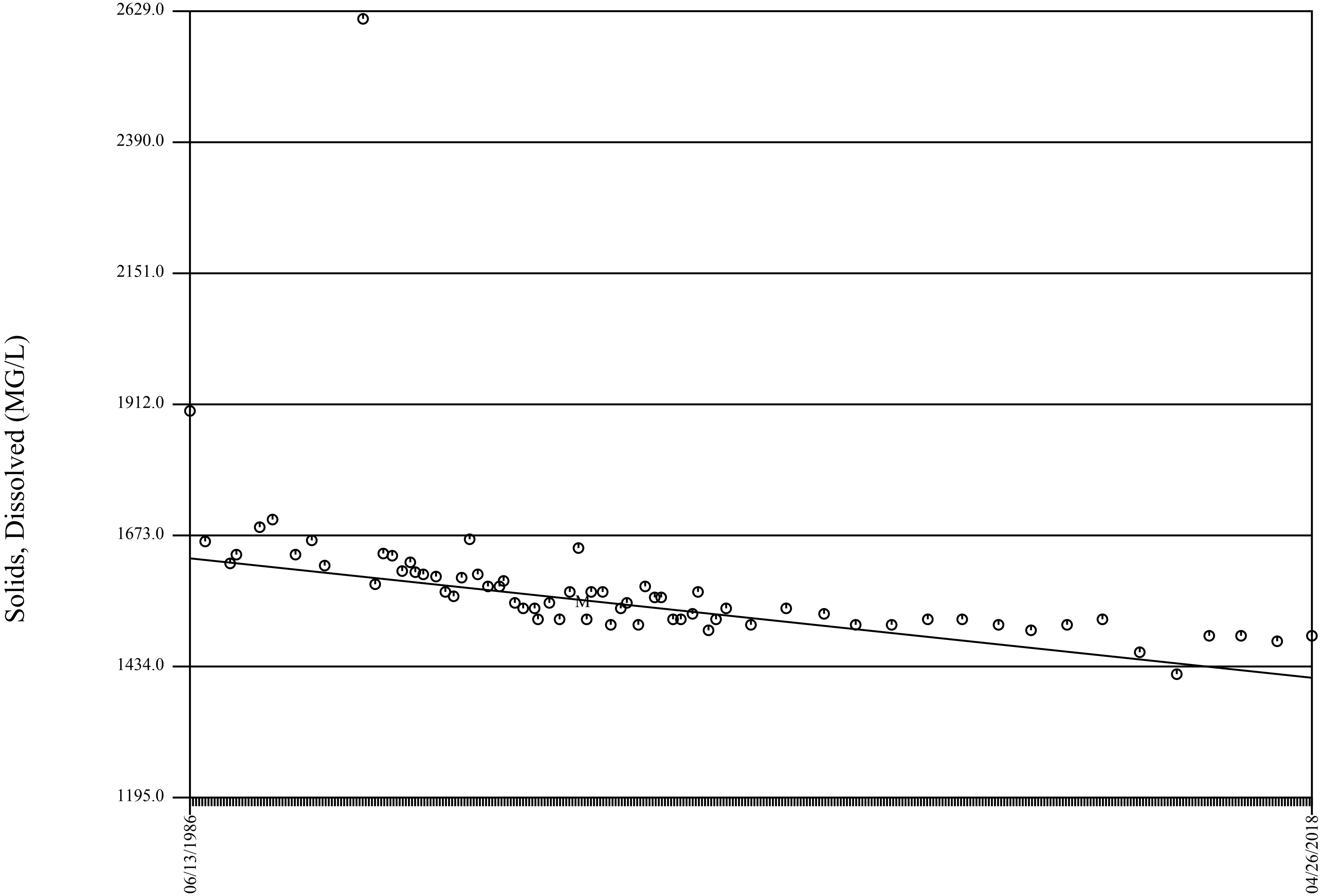
No censored data. -0.0189 Sen trend detected at 10.00% in 90.00% confidence interval -0.0389, -0.0058

WEPO43R



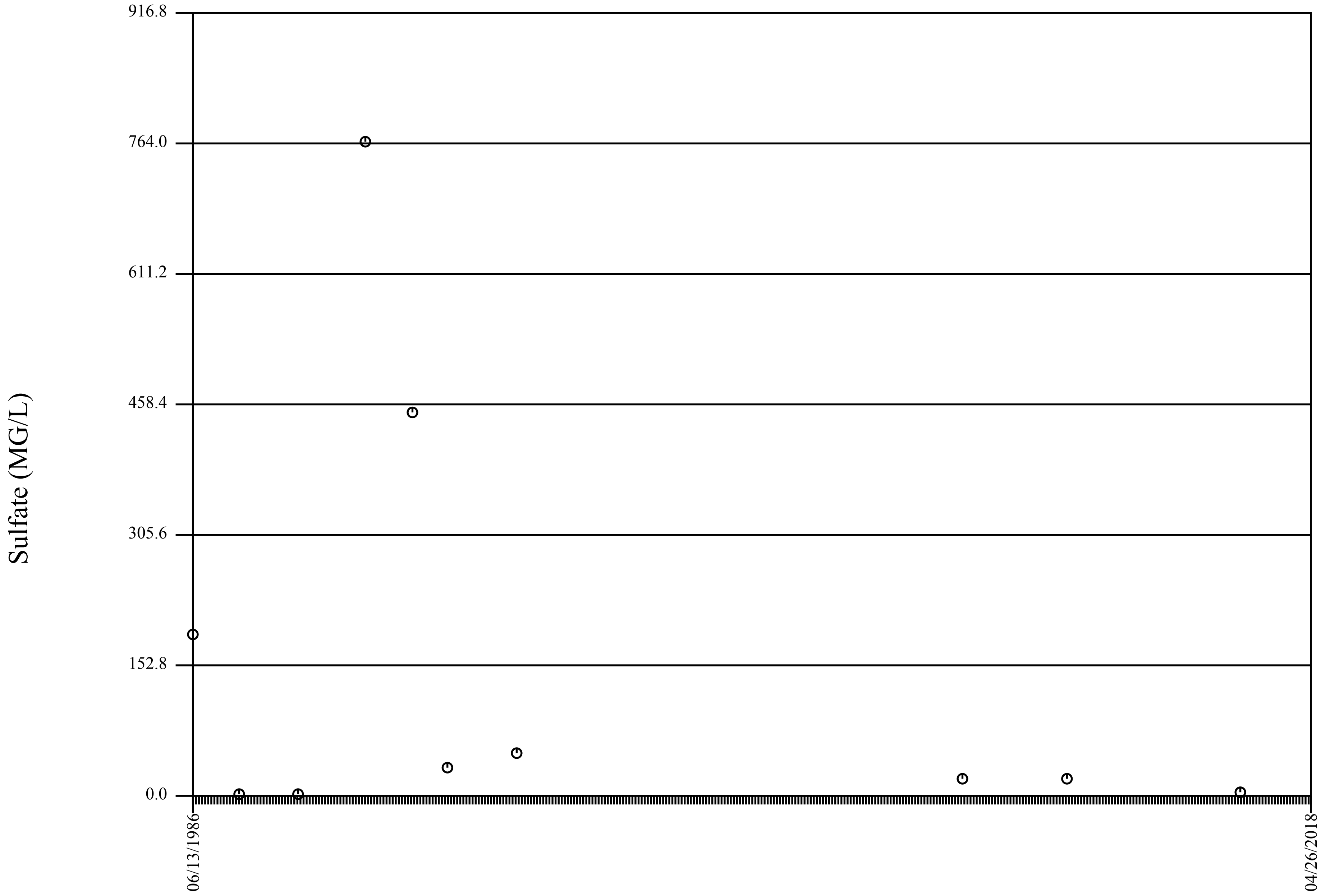
No censored data. -0.0120 Sen trend detected at 10.00% in 90.00% confidence interval -0.0146, -0.0096

WEPO44



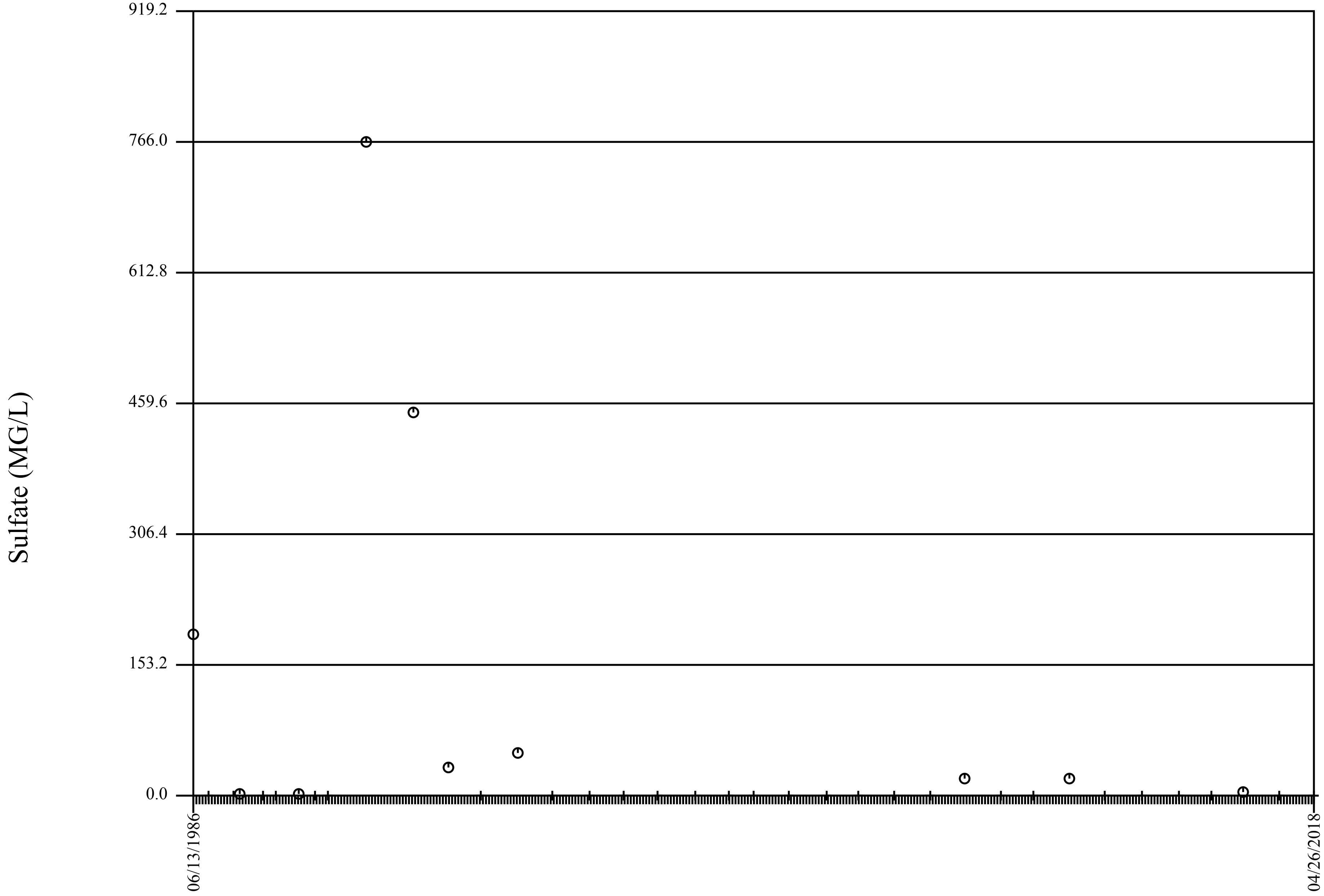
No censored data. -0.0187 Sen trend detected at 10.00% in 90.00% confidence interval -0.0220, -0.0160

WEPO44



No censored data. No trend detected at 10.00%

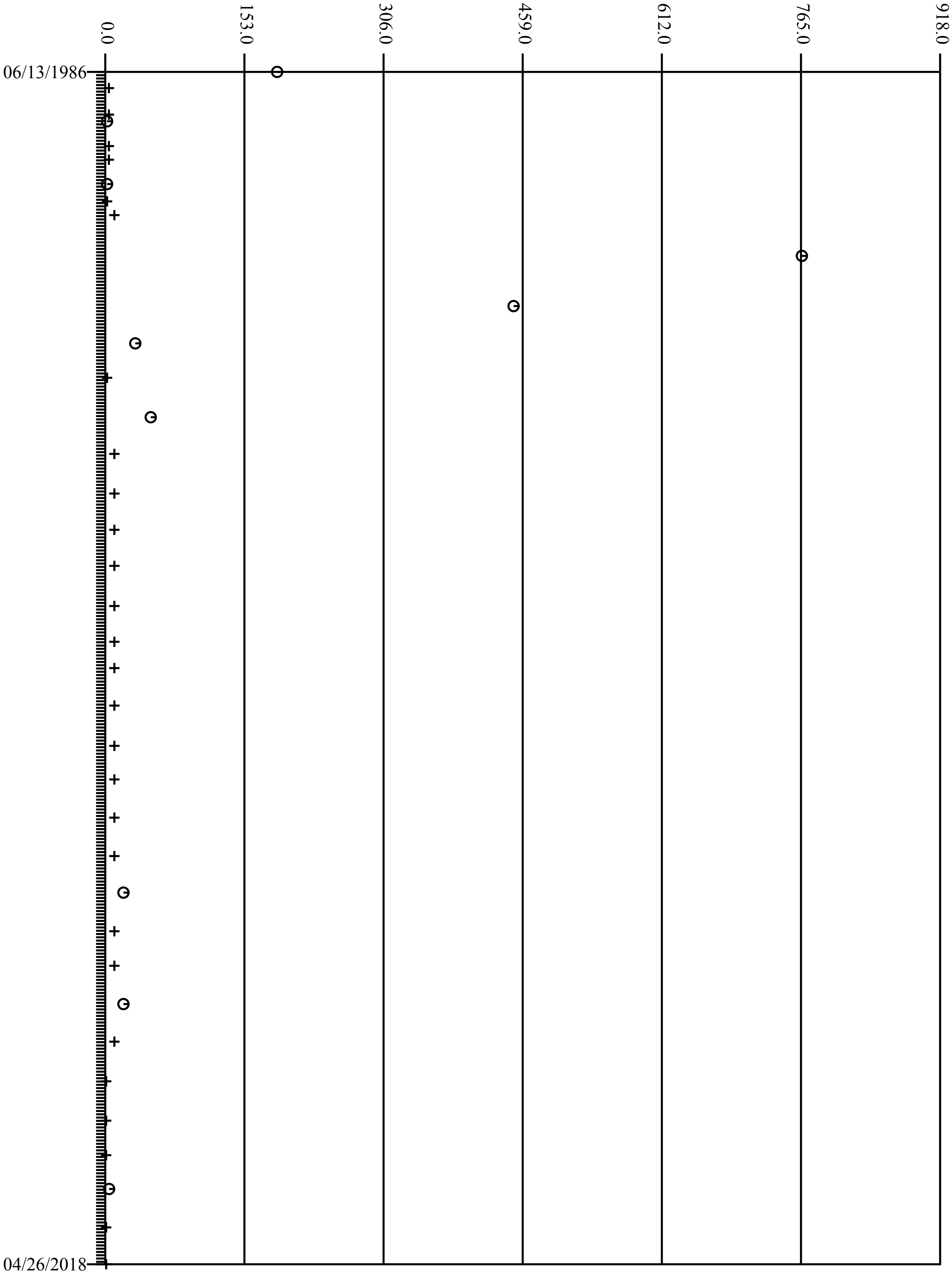
WEPO44



27 censored values at zero. 0.0000 Sen trend detected at 10.00% in 90.00% confidence interval 0.0000, 0.0000

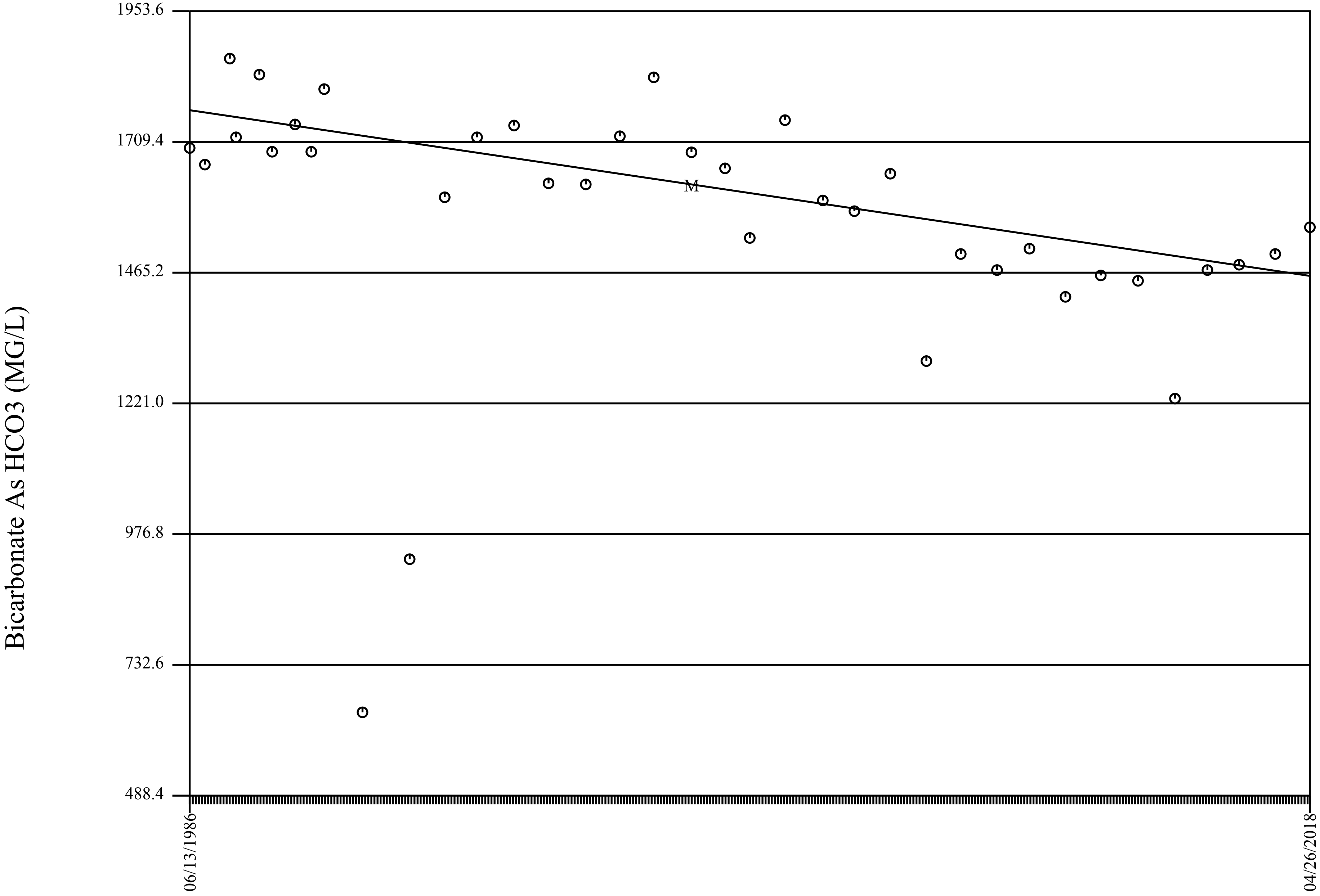
WEPO44

Sulfate (MG/L)



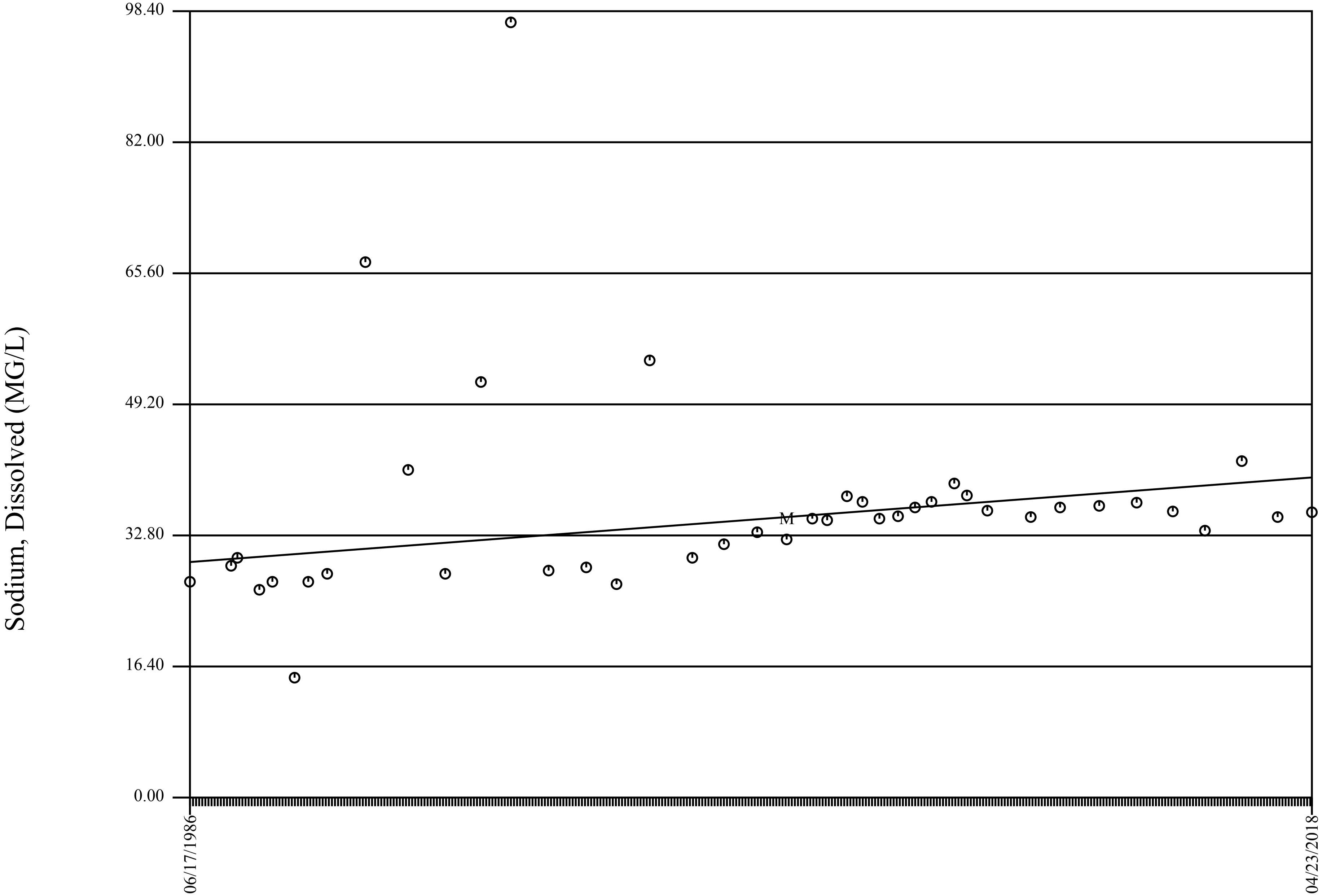
27 censored values at limit. No trend detected at 10.00%

WEPO44



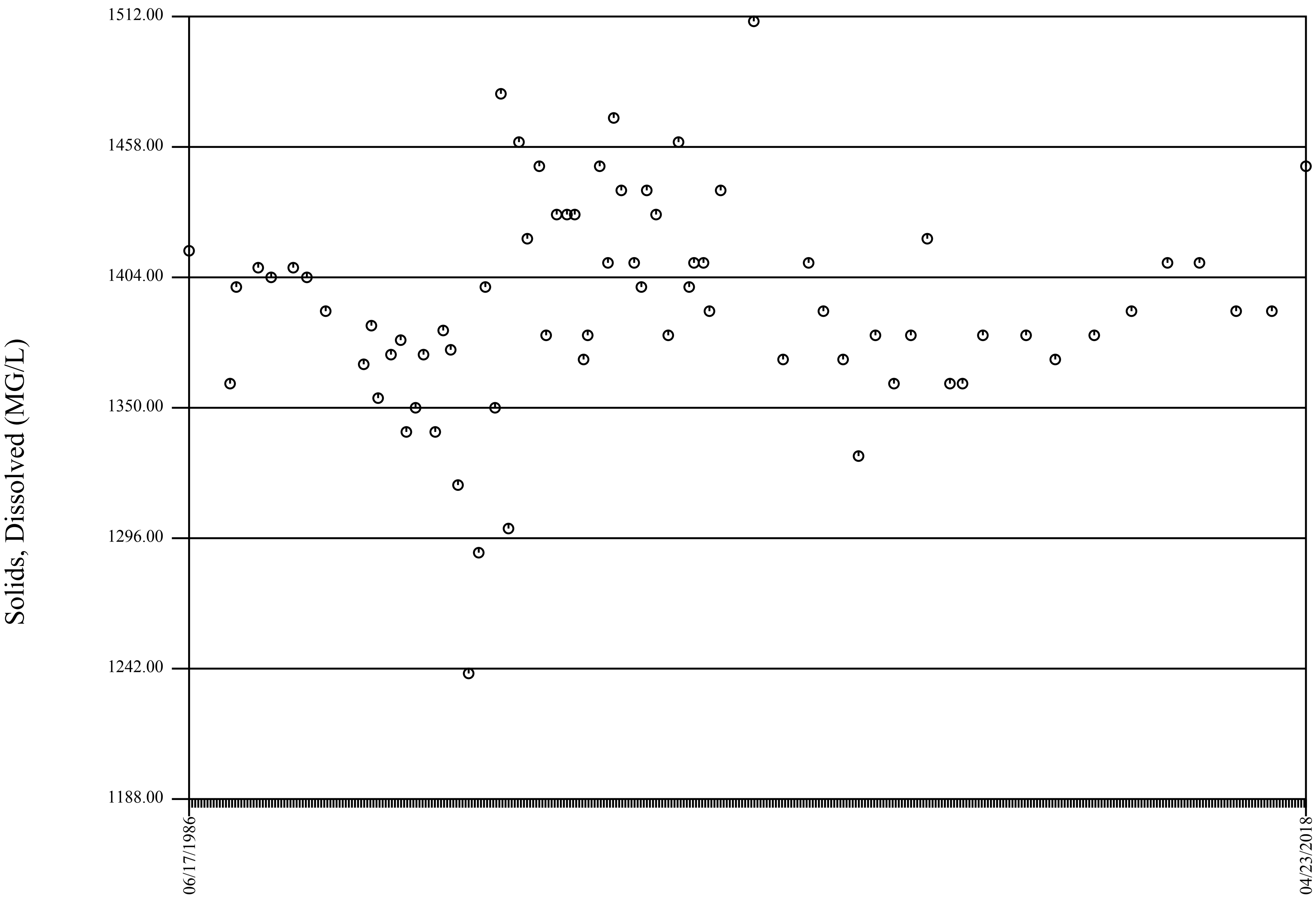
No censored data. -0.0266 Sen trend detected at 10.00% in 90.00% confidence interval -0.0346, -0.0191

WEPO44



No censored data. 0.0009 Sen trend detected at 10.00% in 90.00% confidence interval 0.0006, 0.0012

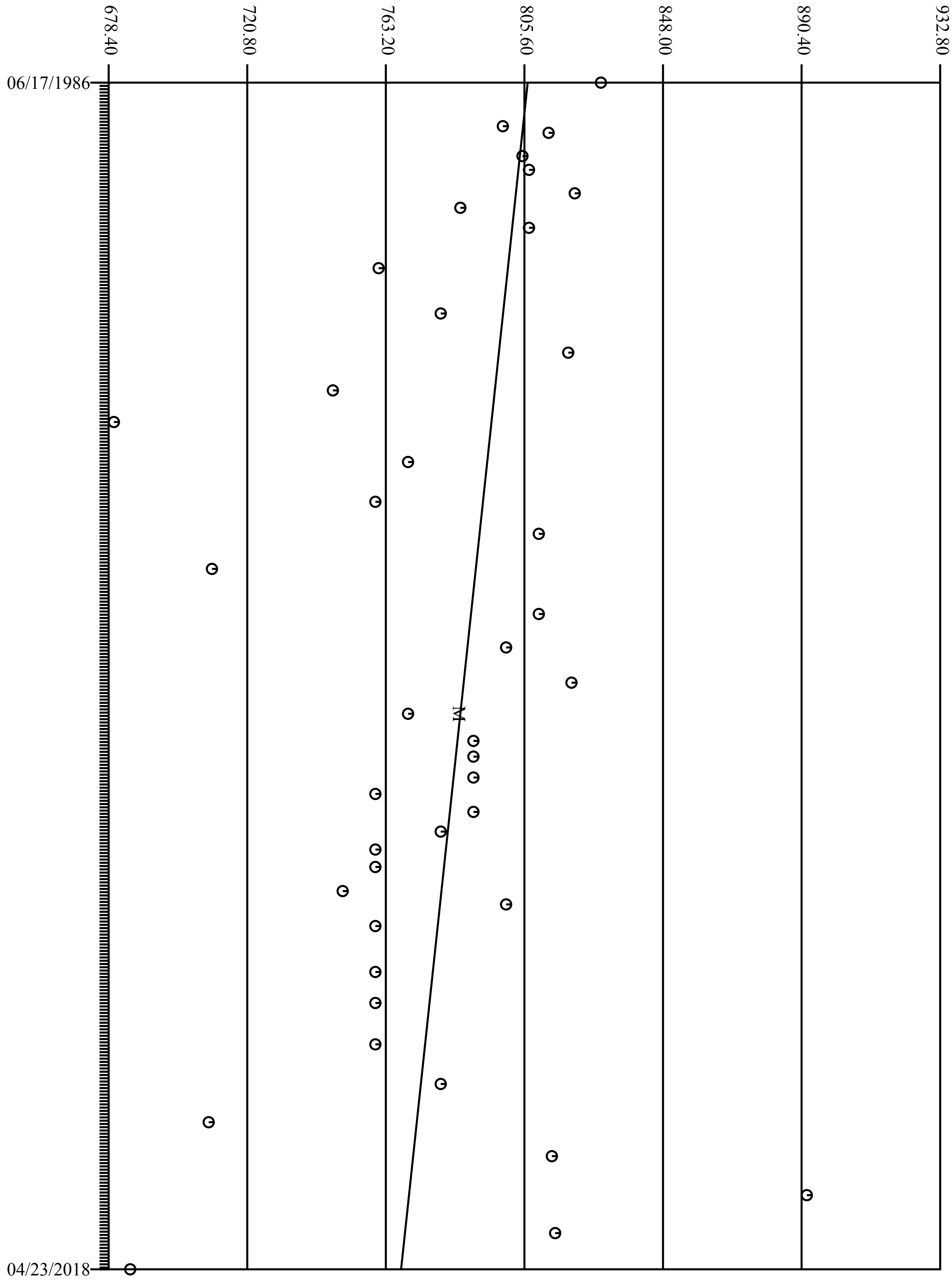
WEPO49



No censored data. No trend detected at 10.00%

WEPO49

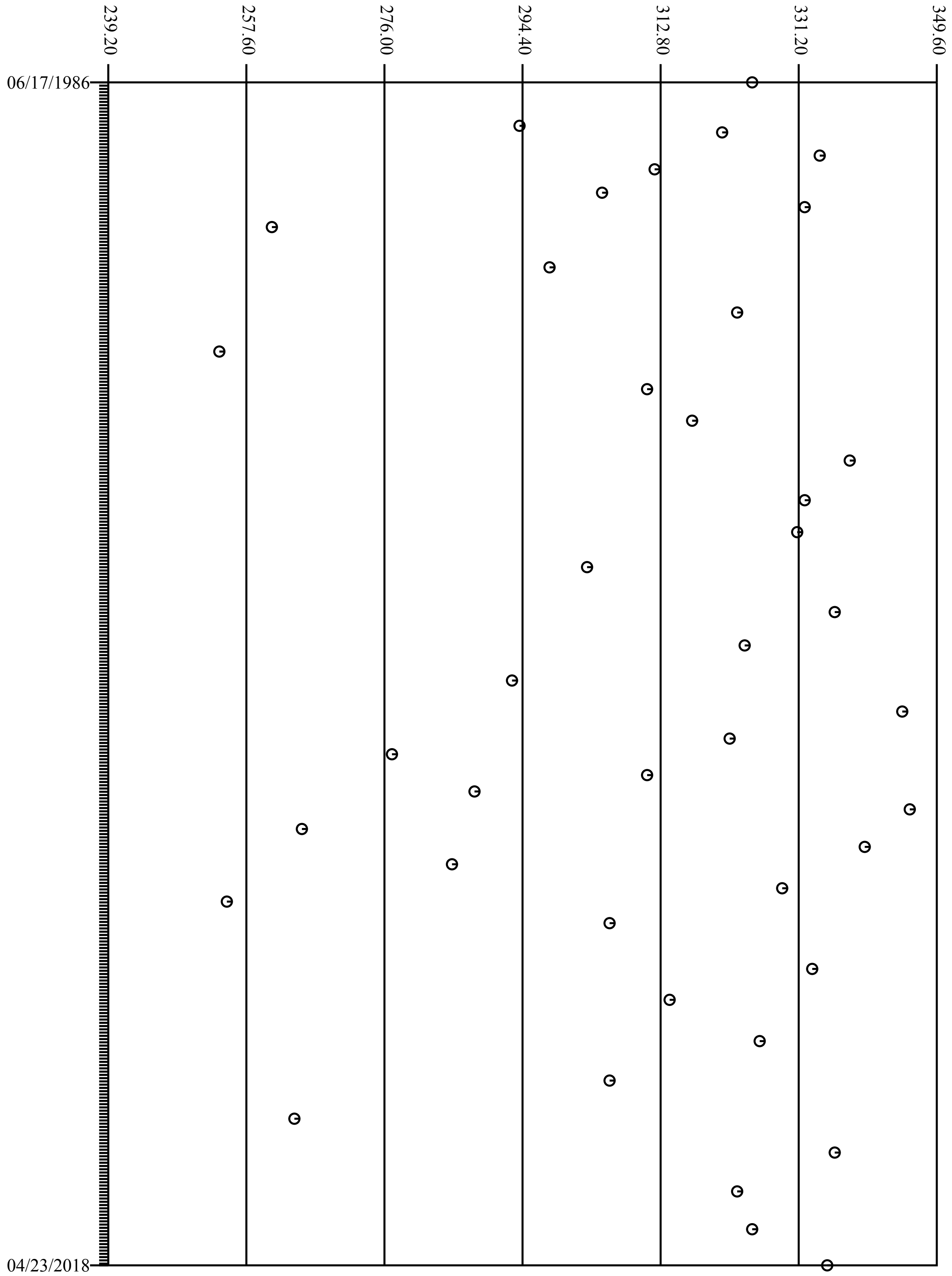
Sulfate (MG/L)



No censored data. -0.0033 Sen trend detected at 10.00% in 90.00% confidence interval -0.0062, -0.0001

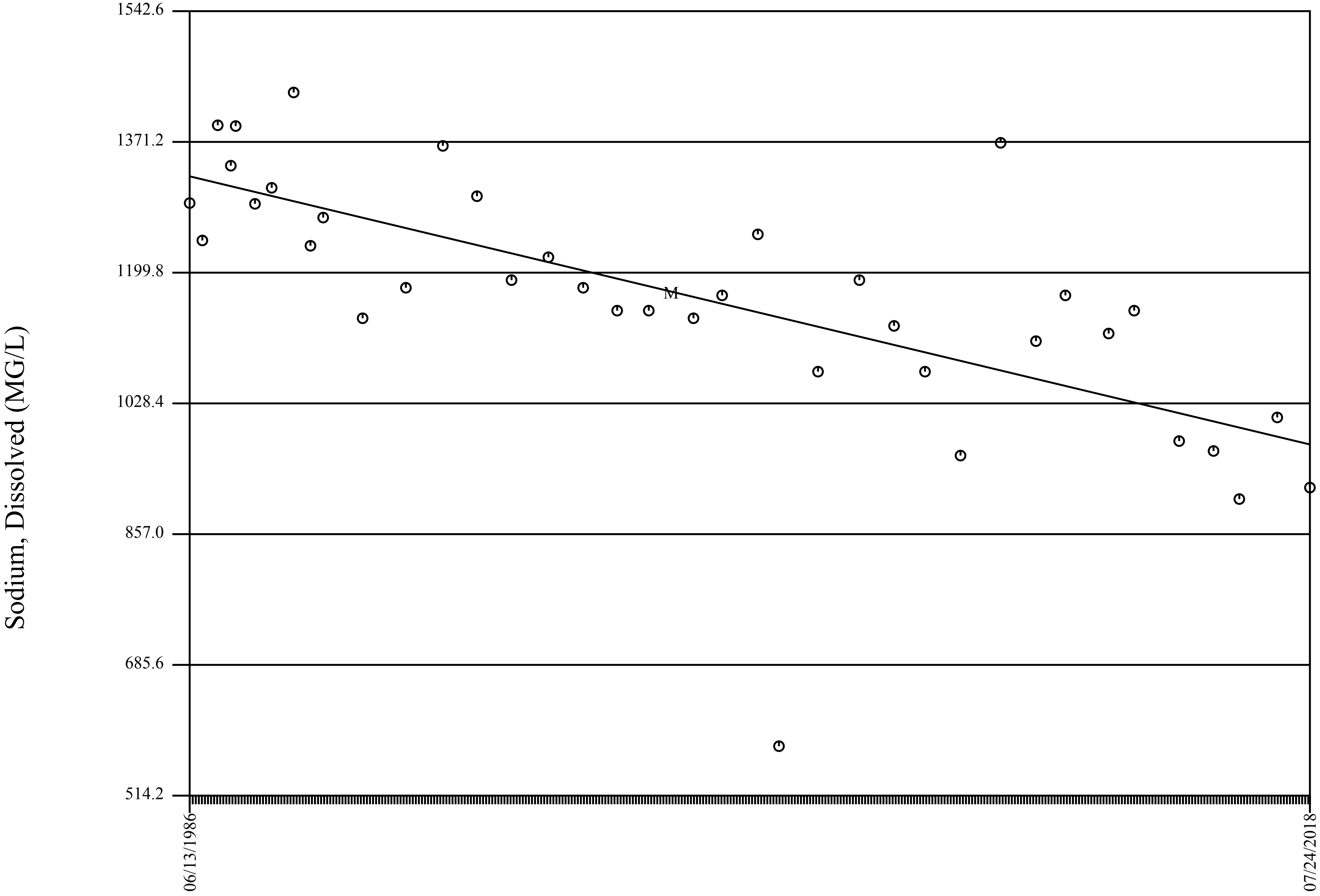
WEPO49

Bicarbonate As HCO3 (MG/L)



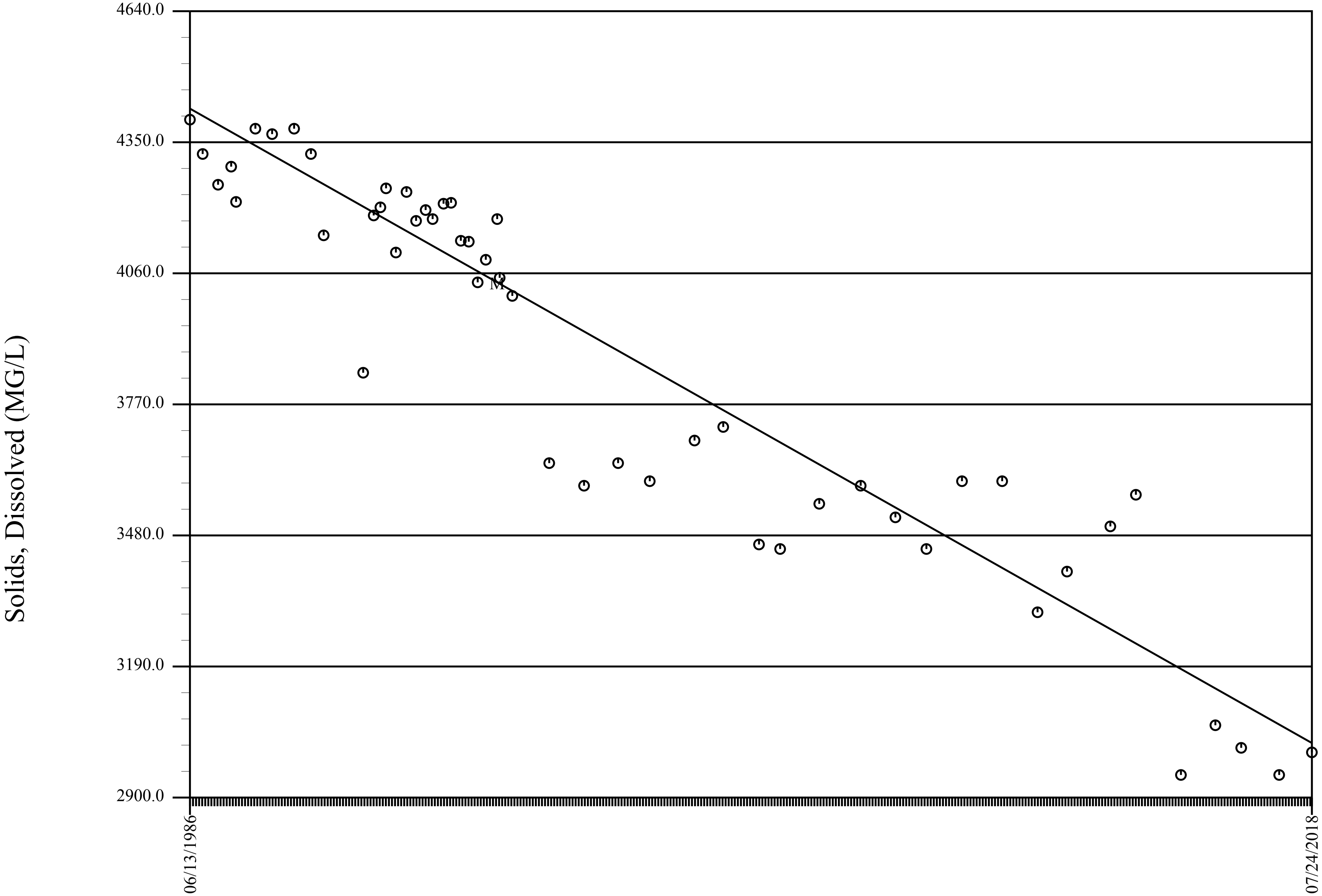
No censored data. No trend detected at 10.00%

WEPO49



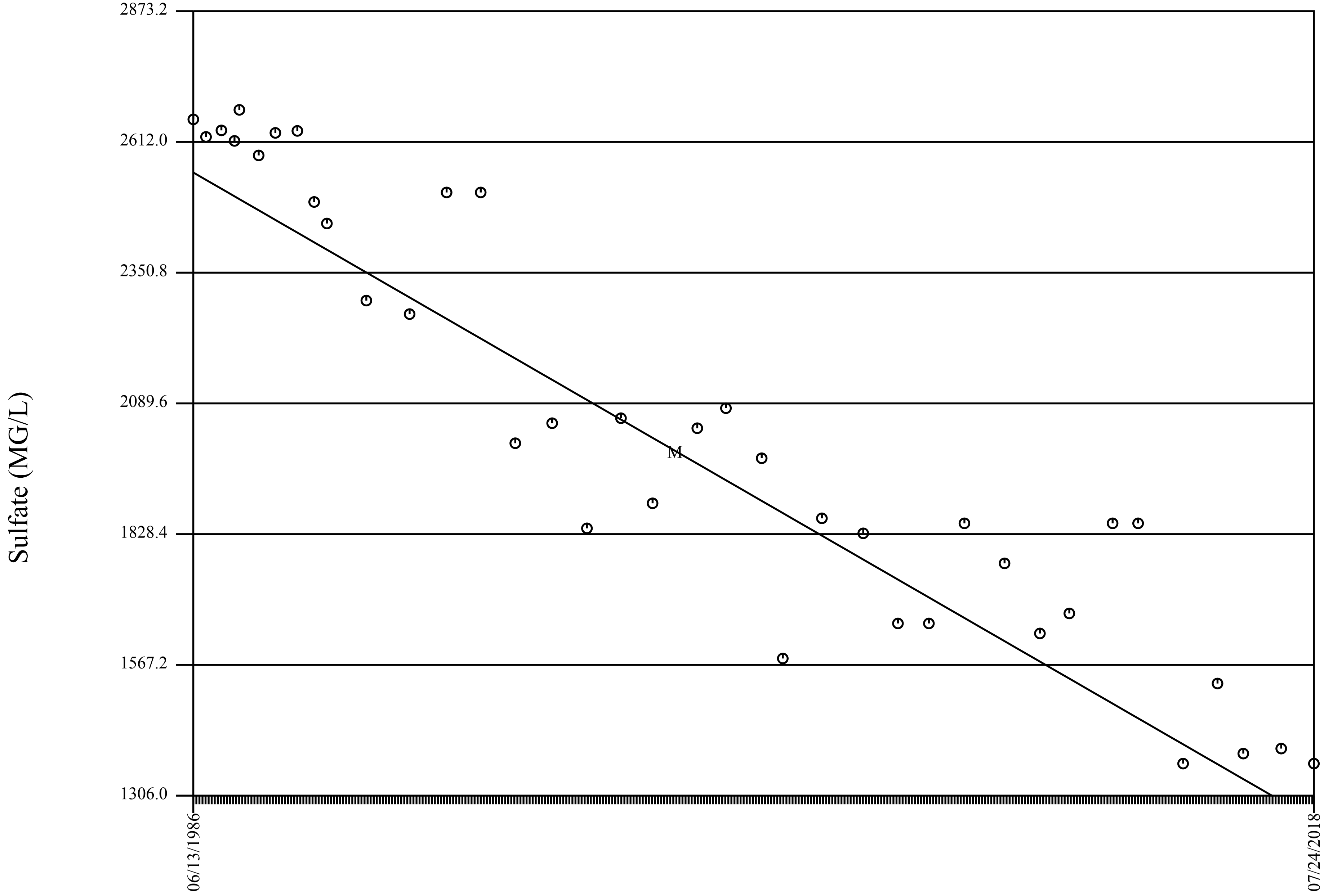
No censored data. -0.0300 Sen trend detected at 10.00% in 90.00% confidence interval -0.0361, -0.0237

WEPO53



No censored data. -0.1197 Sen trend detected at 10.00% in 90.00% confidence interval -0.1315, -0.1073

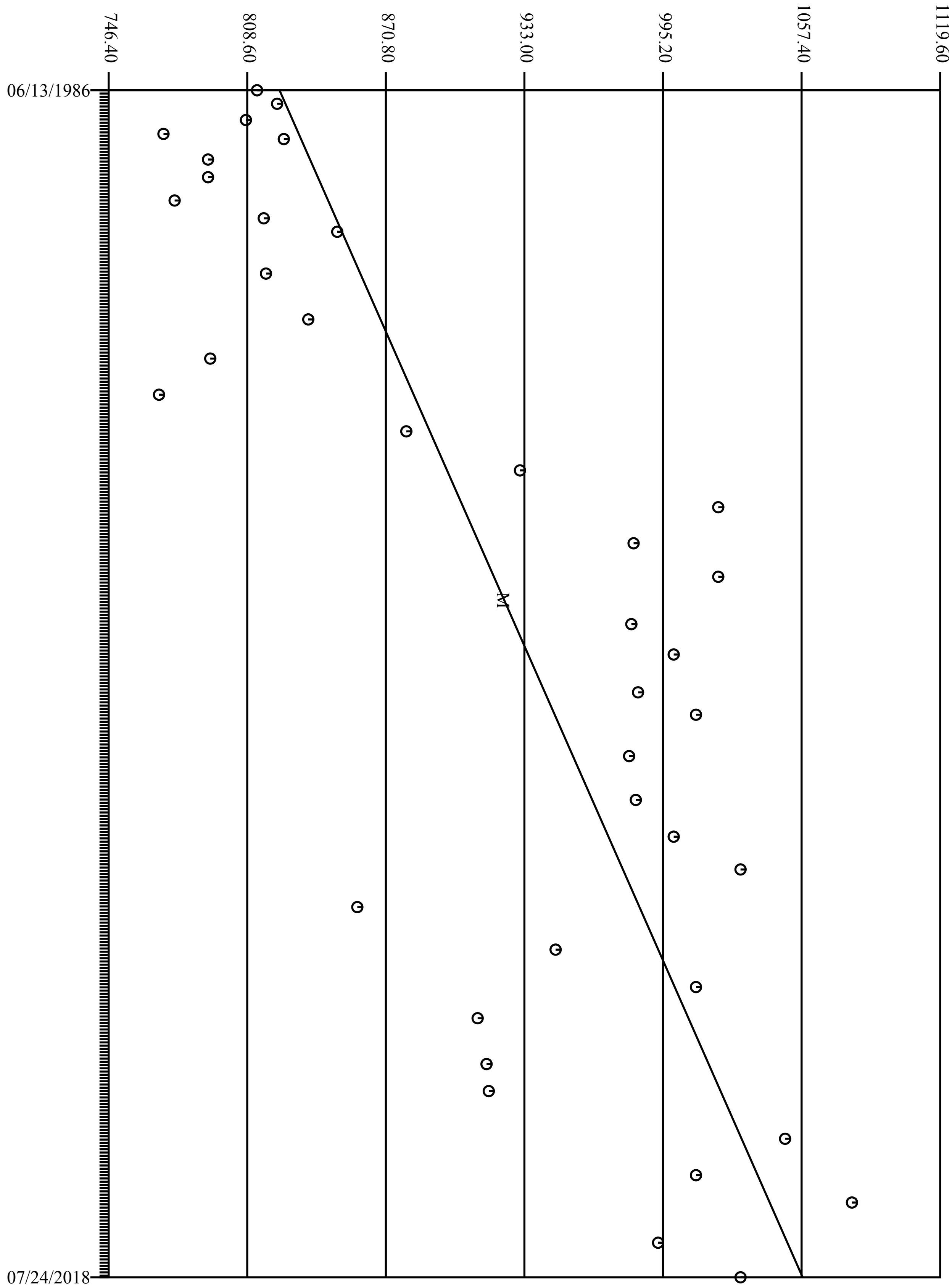
WEPO53



No censored data. -0.1103 Sen trend detected at 10.00% in 90.00% confidence interval -0.1189, -0.0983

WEPO53

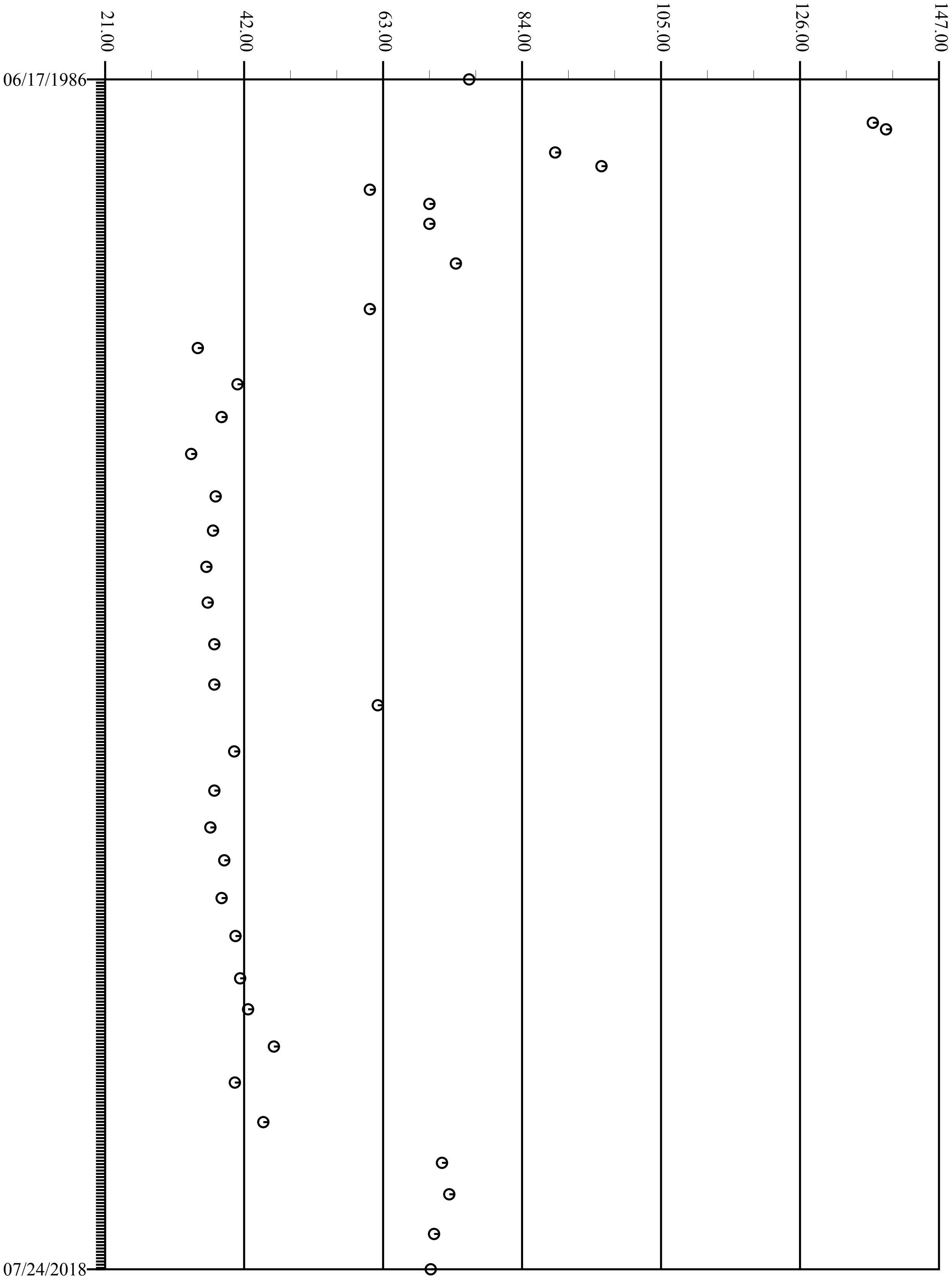
Bicarbonate As HCO3 (MG/L)



No censored data. 0.0200 Sen trend detected at 10.00% in 90.00% confidence interval 0.0145, 0.0256

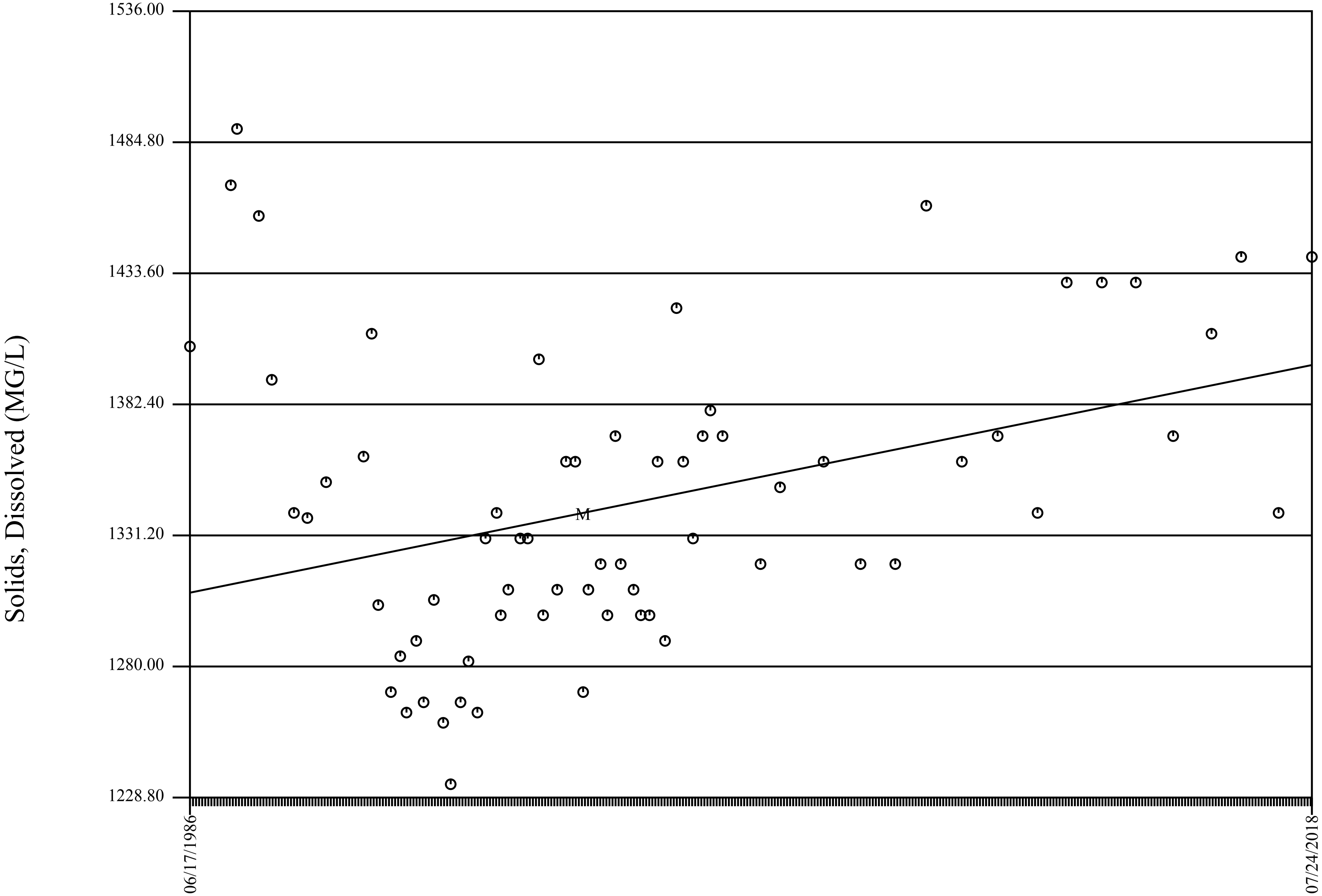
WEPO53

Sodium, Dissolved (MG/L)



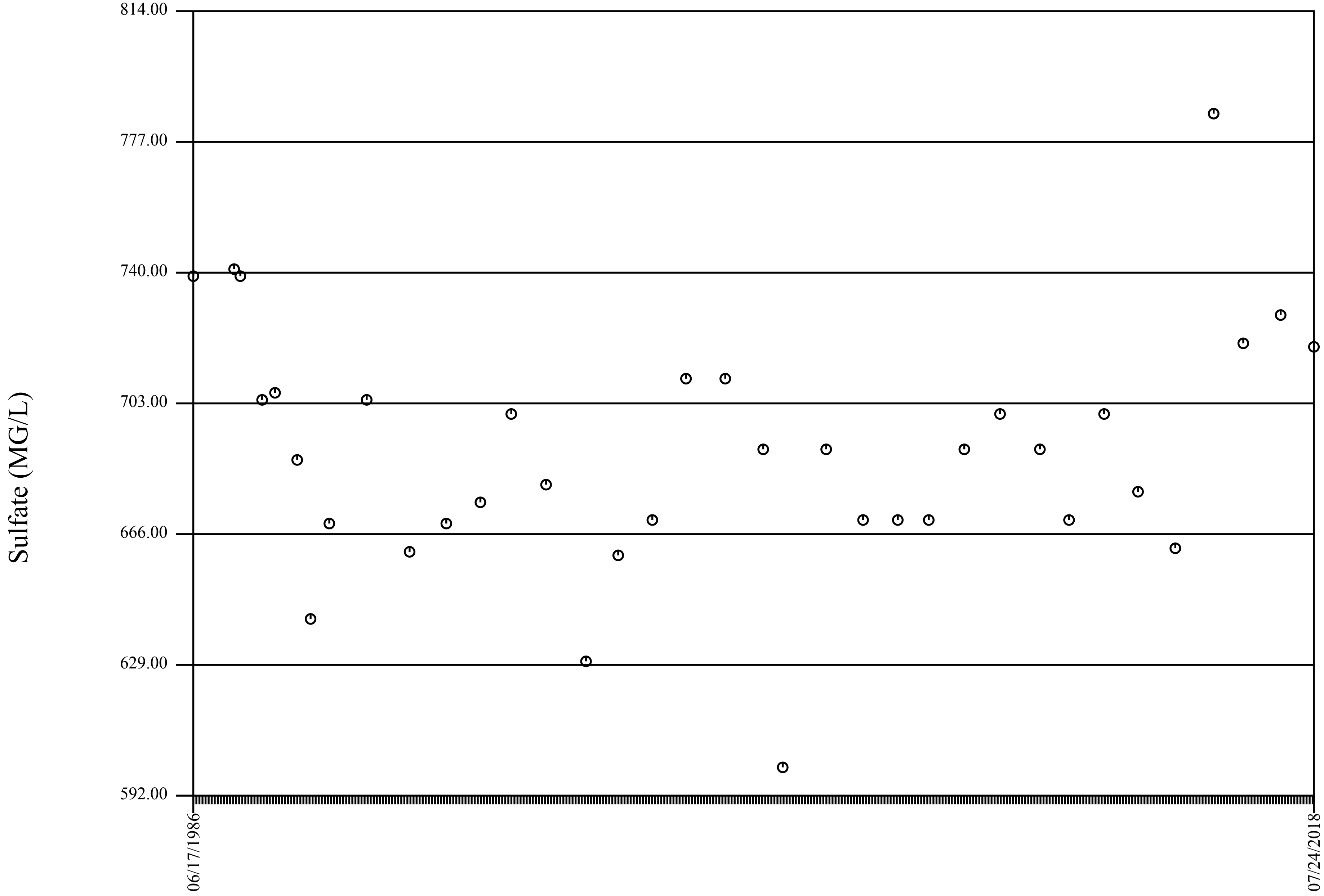
No censored data. No trend detected at 10.00%

WEPO54



No censored data. 0.0076 Sen trend detected at 10.00% in 90.00% confidence interval 0.0030, 0.0122

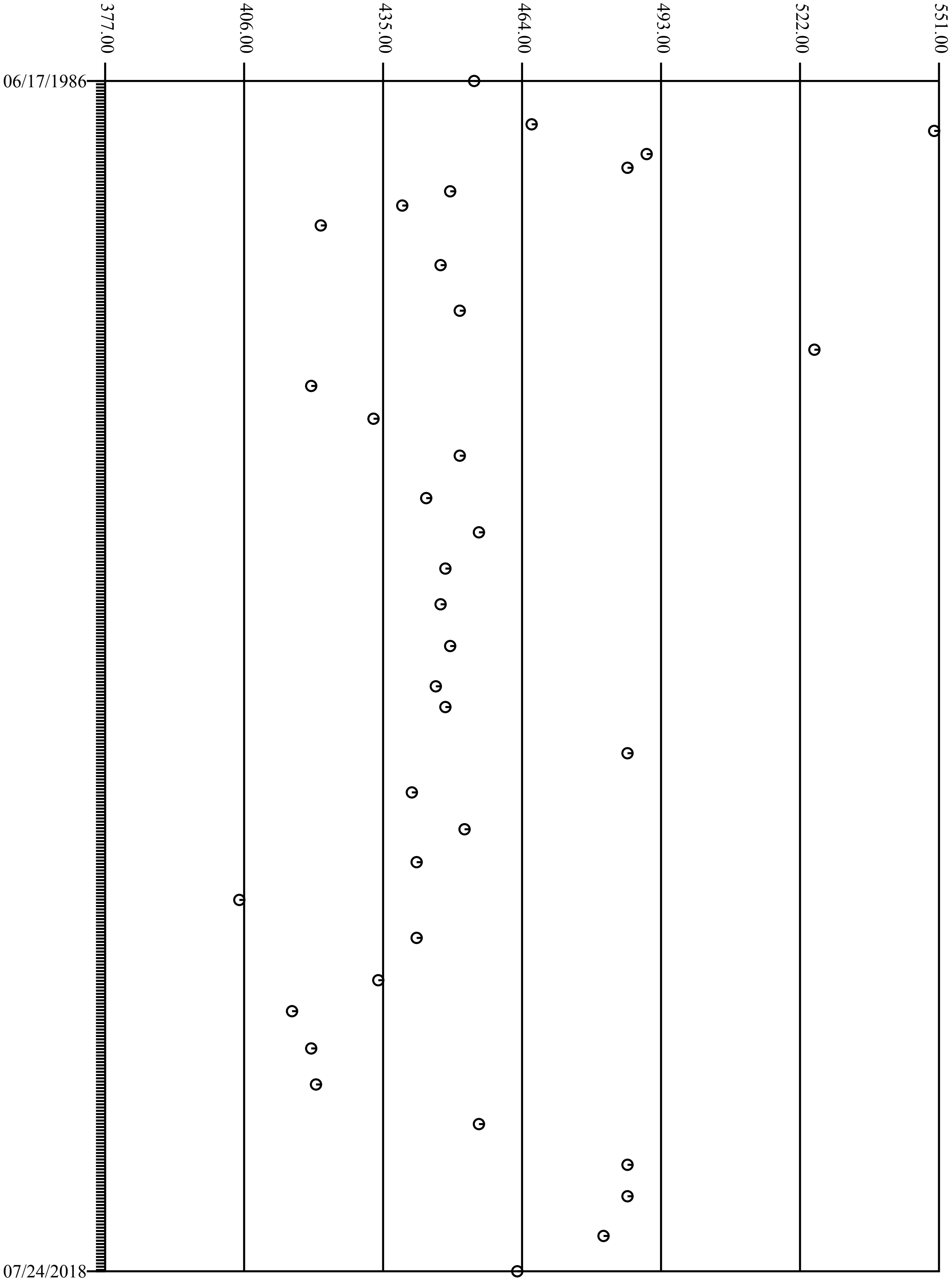
WEPO54



No censored data. No trend detected at 10.00%

WEPO54

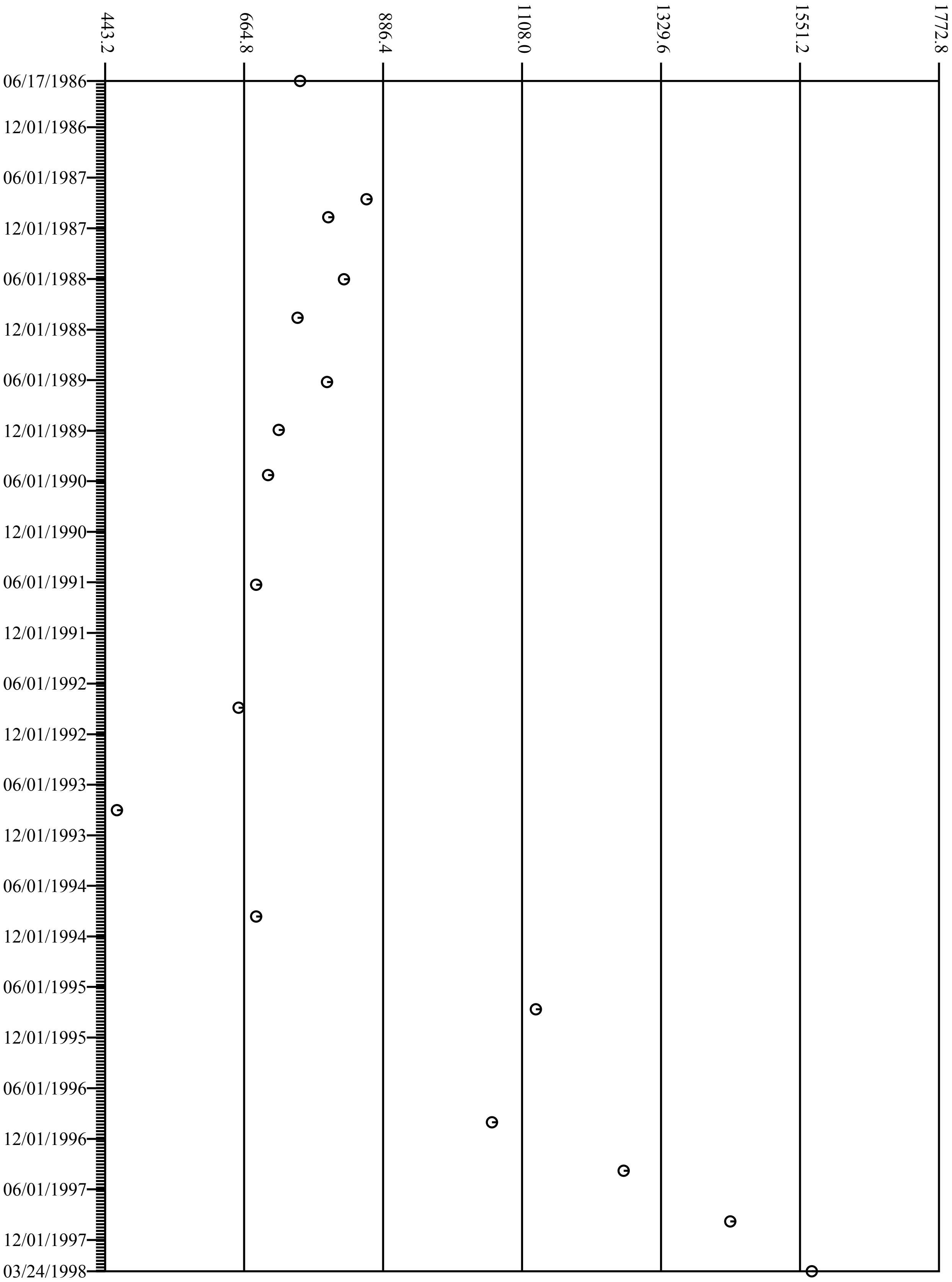
Bicarbonate As HCO3 (MG/L)



No censored data. No trend detected at 10.00%

WEPO54

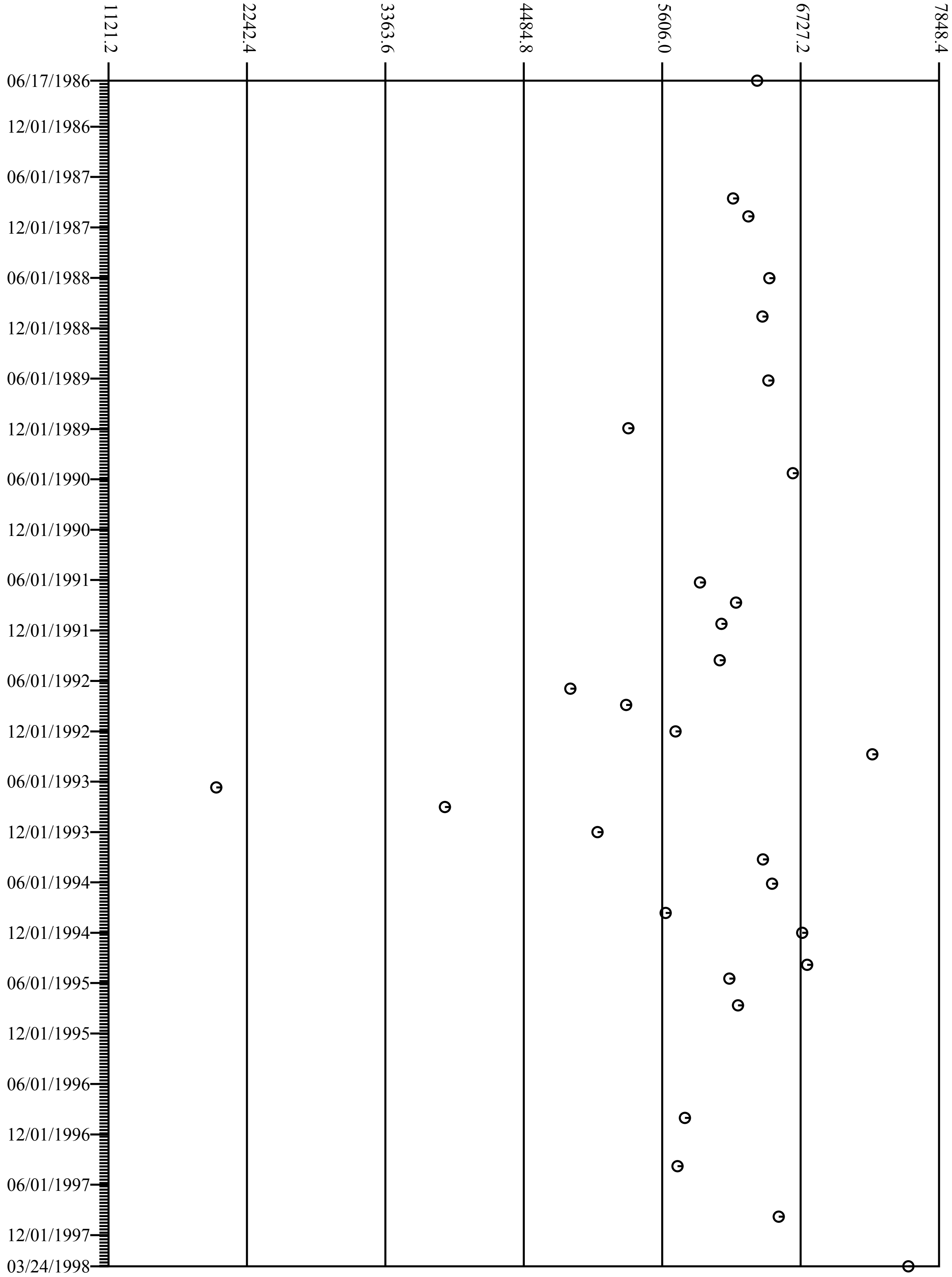
Sodium, Dissolved (MG/L)



No censored data. No trend detected at 10.00%

WEPO62

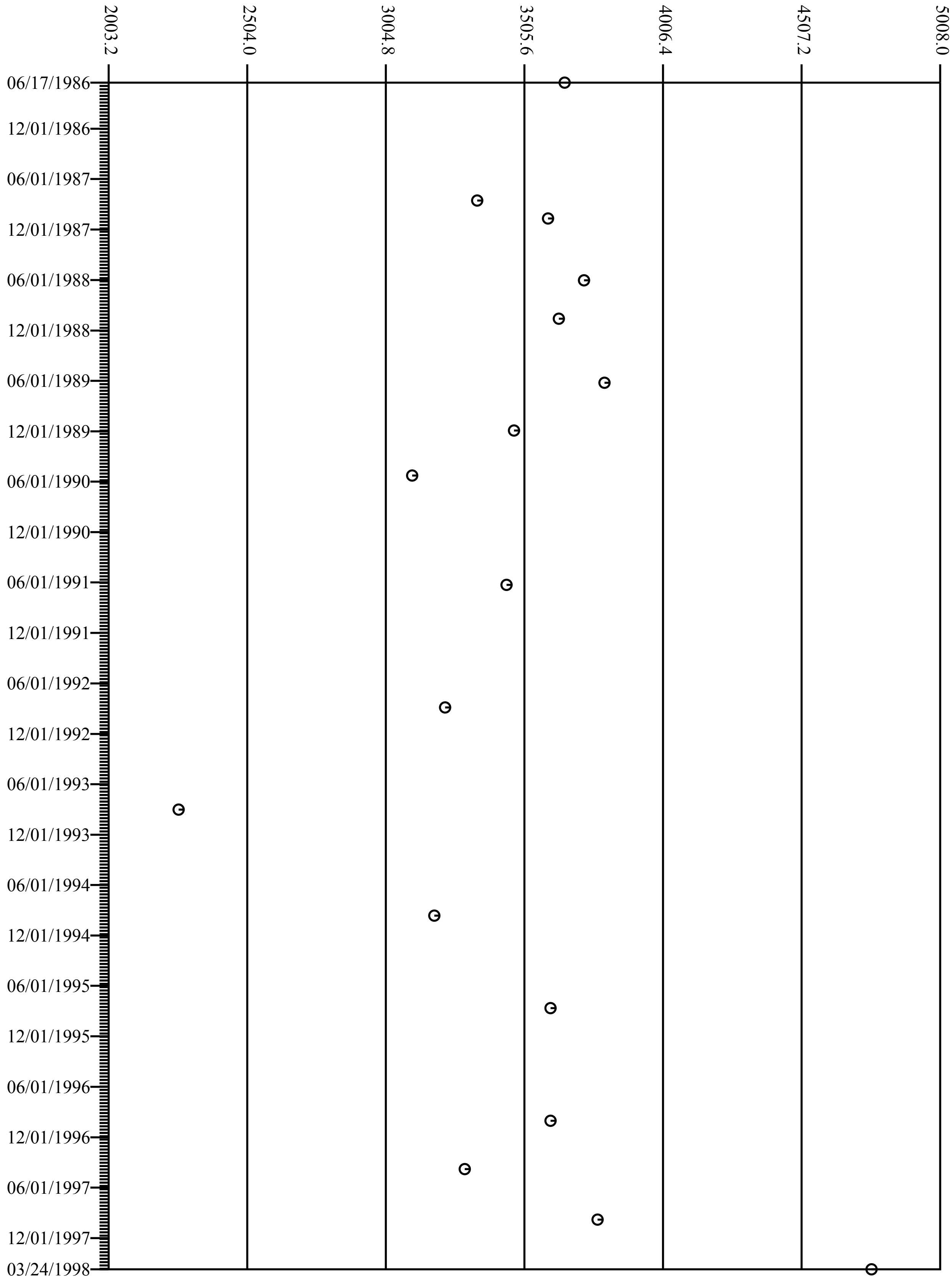
Solids, Dissolved (MG/L)



No censored data. No trend detected at 10.00%

WEPO62

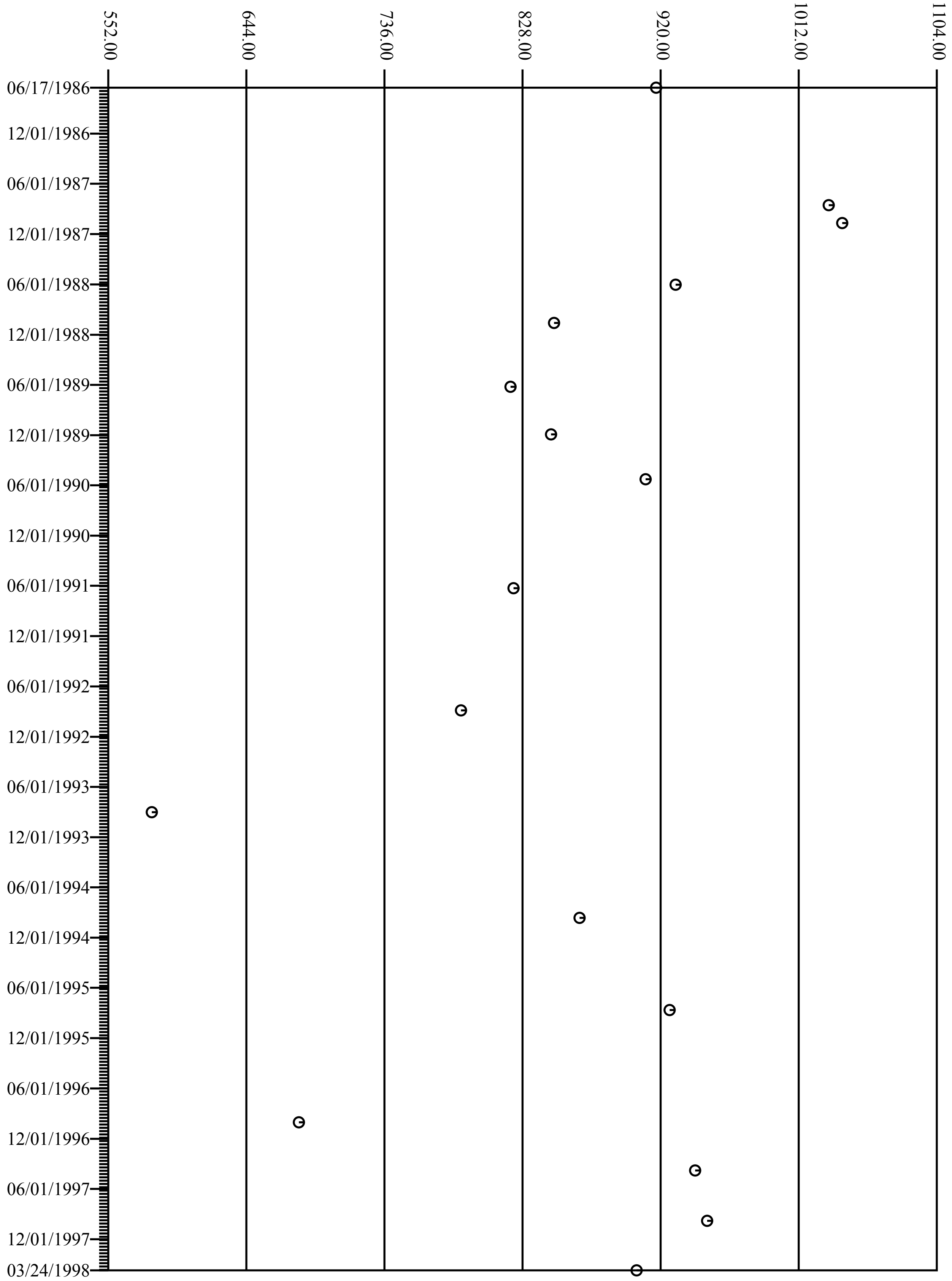
Sulfate (MG/L)



No censored data. No trend detected at 10.00%

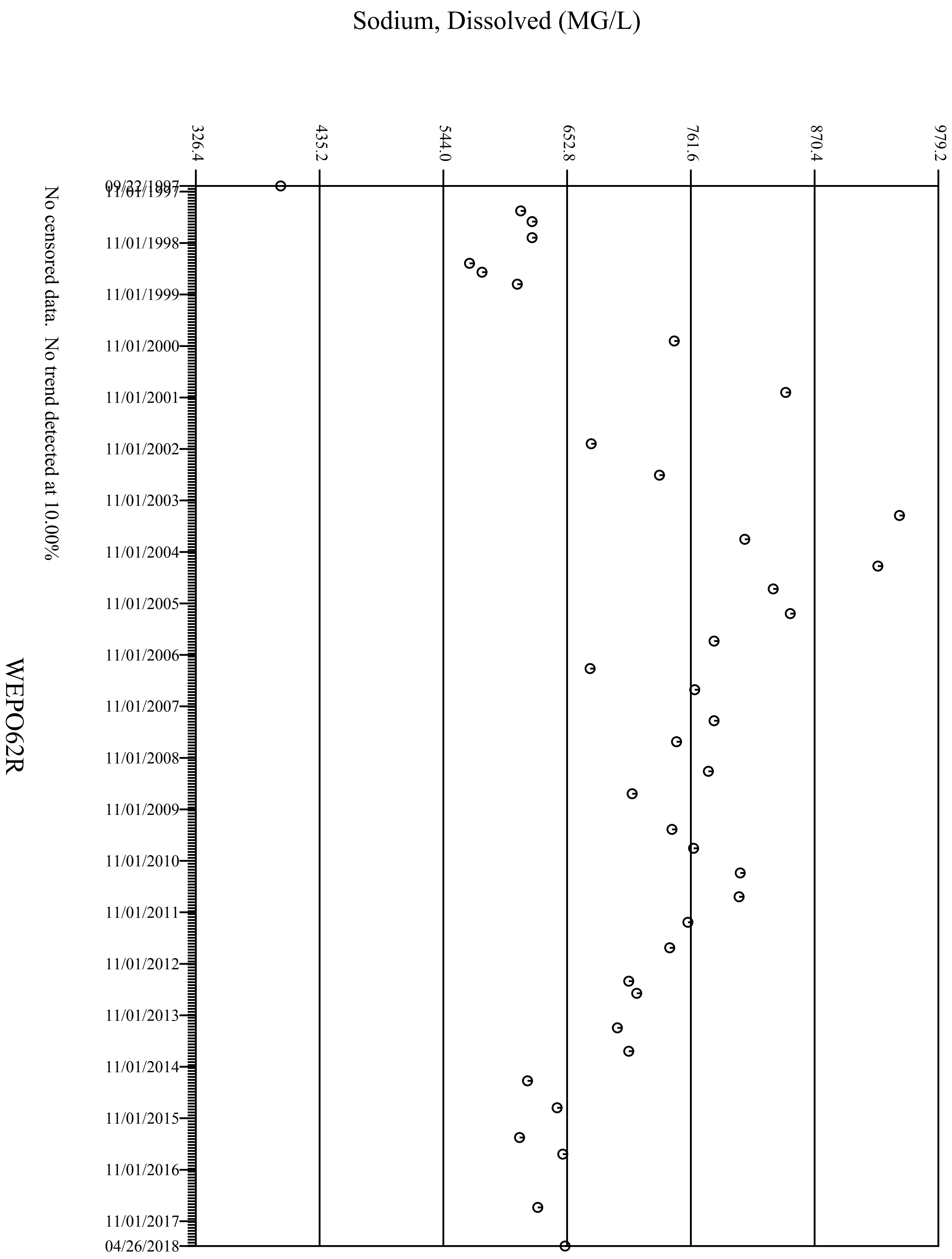
WEPO62

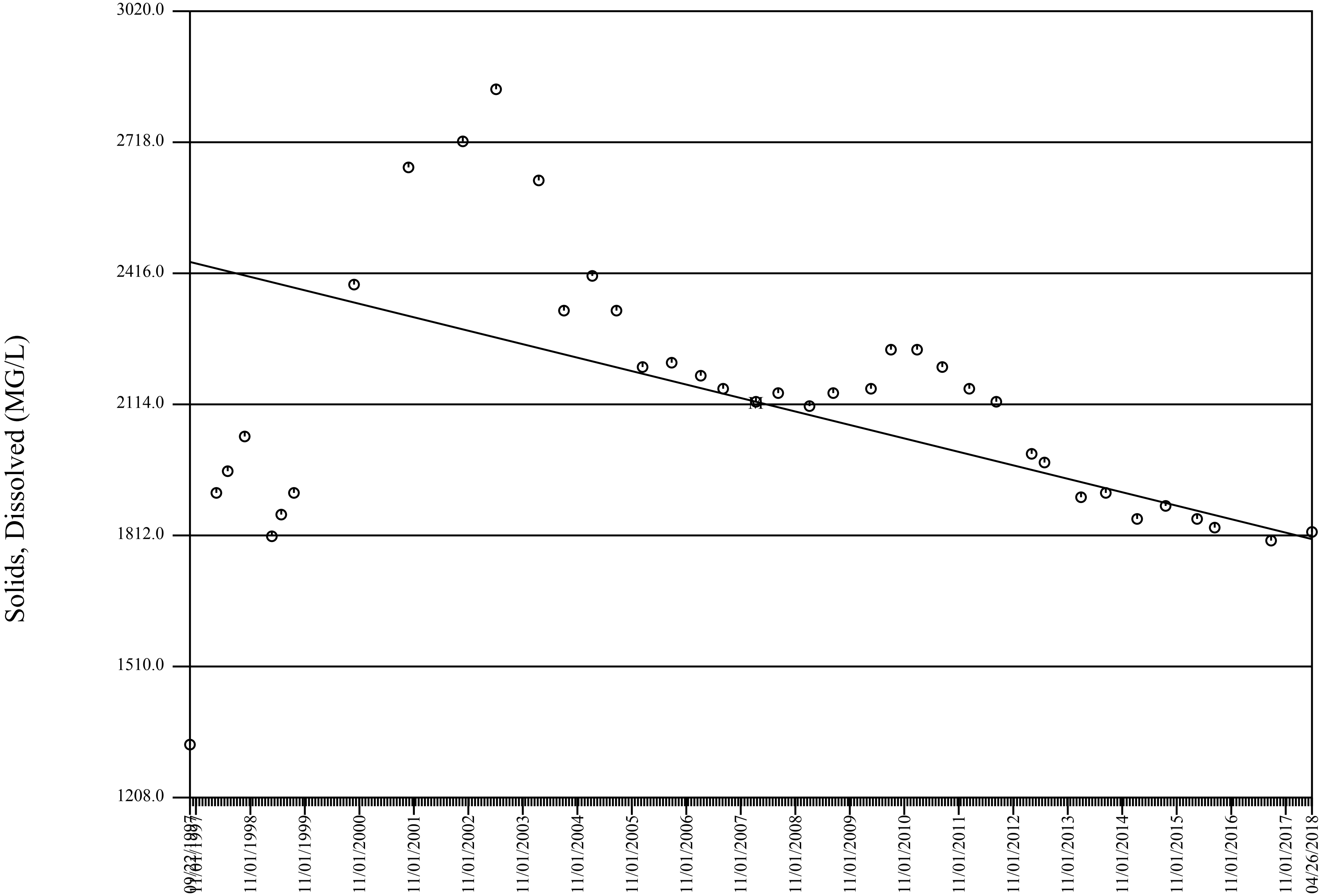
Bicarbonate As HCO3 (MG/L)



No censored data. No trend detected at 10.00%

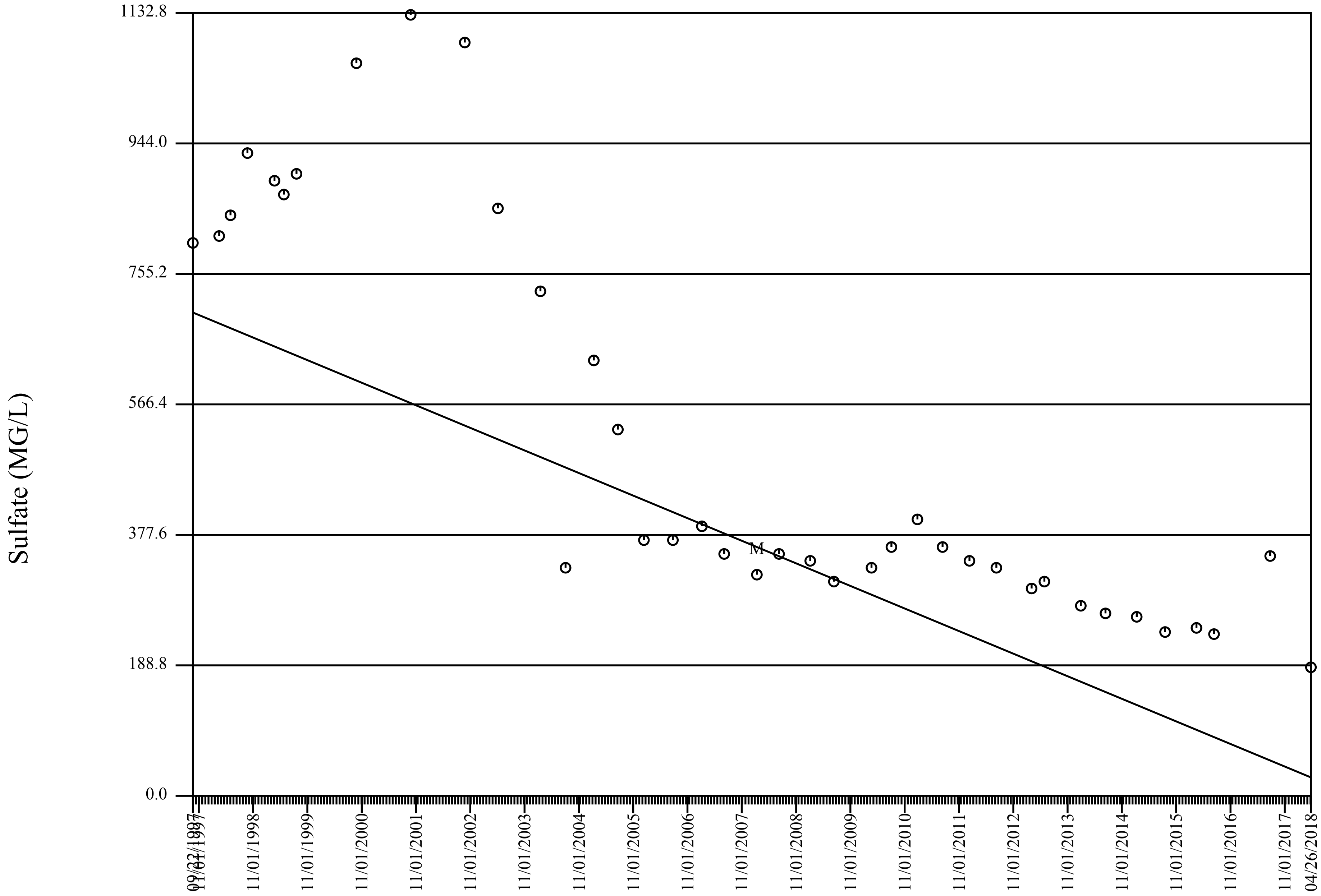
WEPO62


Sodium, Dissolved (MG/L)
326.4
435.2
544.0
652.8
761.6
870.4
979.2
09/22/1997
11/01/1997
11/01/1998
11/01/1999
11/01/2000
11/01/2001
11/01/2002
11/01/2003
11/01/2004
11/01/2005
11/01/2006
11/01/2007
11/01/2008
11/01/2009
11/01/2010
11/01/2011
11/01/2012
11/01/2013
11/01/2014
11/01/2015
11/01/2016
11/01/2017
04/26/2018
No censored data. No trend detected at 10.00%
WEPO62R



No censored data. -0.0849 Sen trend detected at 10.00% in 90.00% confidence interval -0.1030, -0.0275

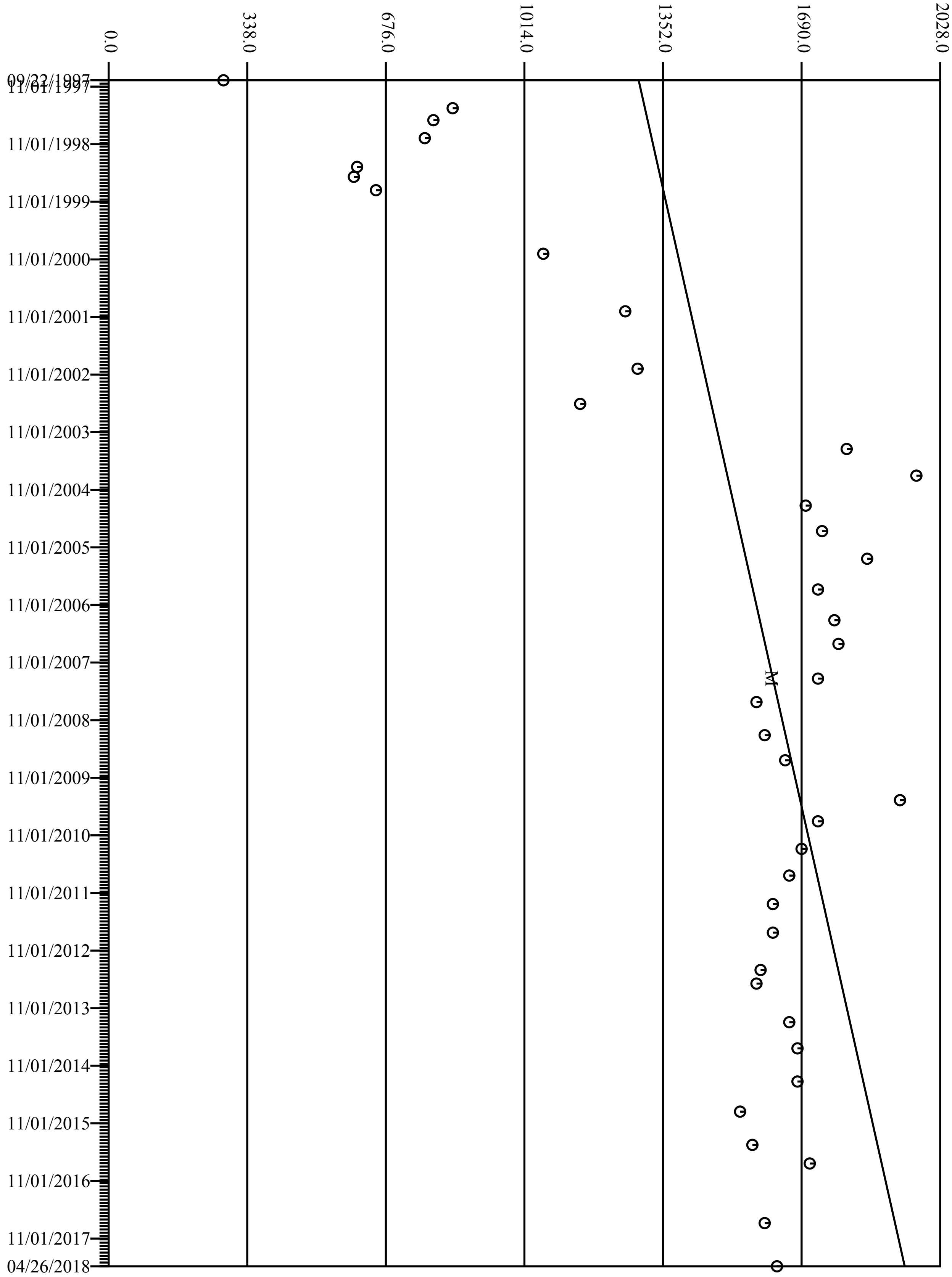
WEPO62R



No censored data. -0.0894 Sen trend detected at 10.00% in 90.00% confidence interval -0.1086, -0.0677

WEPO62R

Bicarbonate As HCO3 (MG/L)



No censored data. 0.0863 Sen trend detected at 10.00% in 90.00% confidence interval 0.0077, 0.1373

WEPO62R

Attachment 3-5a

Surface Water Modeling of the Reclaimed Parcels at
Black Mesa Complex J1/N6 and N6 East Central Coal Resource Areas

SURFACE WATER MODELING OF THE RECLAIMED PARCELS AT BLACK MESA COMPLEX J1/N6 AND N6 East Central COAL RESOURCE AREAS

Prepared for

Peabody Western Coal Co.
Highway 160, Navajo Route 41
Kayenta, Arizona 86033

AYRES
ASSOCIATES

SURFACE WATER MODELING OF THE RECLAIMED PARCELS AT BLACK MESA COMPLEX J1/N6 AND N6 EAST CENTRAL COAL RESOURCE AREAS

Prepared for

Peabody Western Coal Co.
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Ayres Project No. 32-1304.01
PEA-N6EC.DOC

September 2009

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1. RECLAIMED PARCEL MODELING

1.1 Introduction

The purpose of this project is to use a previously calibrated and validated runoff and erosion model EASI - Erosion And Sediment Impacts (Zevenbergen et al. 1990; WET 1990) for the Black Mesa and Kayenta Mines (combined as Black Mesa Complex in December 2008) to predict mean annual runoff and sediment yields from the reclaimed parcel J1/N6 and N6 East Central. Since the model for the J1/N6 Coal Resource Area (CRA) was completed in 2001, the objectives of this project are to review the completed J1/N6 model, develop a model for the neighboring N6 East Central CRA, and incorporate the newly developed N6 East Central model into the existing J1/N6 model. The response of the reclaimed parcels was evaluated relative to undisturbed (premine) conditions in the corresponding undisturbed watersheds. All soils and rainfall input to the model are to be taken from models calibrated in the previous study (RCE 1993). The input variables that were calibrated to the mine areas and used in this study include soil infiltration parameters, erodibility parameters, and the grain size distribution. Parameters that are specific to this study are vegetative canopy and ground cover percentages from data collected on site. The model serves a tool for assessing the success of reclamation efforts to protect hydrologic balance (30 CFR 715.17 and 30 CFR 816.41).

The model calibration was conducted in a previous study (RCE 1993) using data obtained from instrumented watersheds and small hillslope plots collected under natural rainfall conditions. For a detailed discussion of data collection and model calibration, please refer to the previous study (RCE 1993).

1.2 Background

The J1/N6 and N6 East Central CRA that is the focus of this project was reclaimed between 1981 and 2007. This reclaimed area is now eligible for termination of jurisdiction from the Office of Surface Mining Regulation and Enforcement (OSMRE). The fundamental purpose of this study was to quantify the expected behavior and hydrologic response of the current conditions of reclaimed areas relative to the conditions that existed prior to the occurrence of mining activities.

Runoff and sediment yield response from the reclaimed lands should be managed by implementing Best Management Practices (BMP's) in conjunction with an OSM approved sediment control plan in order to not adversely impact the prevailing hydrologic balance and to limit additional contributions of suspended sediment to streamflow or runoff outside the mine permit areas. BMP's include regrading, replacing salvaged topsoil, revegetation, and other controls such as riprapped channel bottoms, check dams, and where practicable, contour terraces. The natural watersheds on the mesa contribute significant quantities of sediment to the channel system. It is expected that the postmine condition will also produce comparable amounts of sediment without adversely impacting the hydrologic balance.

This section describes the data and procedures used to evaluate the CRA J1/N6 and N6 East Central. This area was modeled to determine the average annual hydrologic response following the completion of reclamation activities and maturation of the reclaimed area vegetation taking into account BMP's implemented as part of the reclamation process. Infiltration, runoff, and erosion processes from both hillslopes and channels within the CRA were modeled using EASI. Results were determined for concentration points at the outlets of the reclaimed watersheds. The locations of these points are shown in **Exhibit 1**. Modeling was also conducted to determine hydrologic response under premine conditions based on the topography, soils, cover, and other conditions that typified the undisturbed watersheds draining to each concentration point. **Exhibit 2** shows the modeling endpoints for the J1/N6 and N6 East Central premining watersheds.

1.3 Data

1.3.1 Soils

Soils data used for the current study (CRA J1/N6 and N6 East Central) were based on data developed from the calibration of models used in the previous study for Coal Resource Areas (CRAs) N1/N2 and J27 (RCE 1993). The composition of postmine soil in the current study is depicted along with the composition of postmine soils from the previous study in **Figure 1.1**. This figure shows that the soil composition of CRA J1/N6 and N6 East Central is very similar to soils evaluated during model calibration. Therefore, the soil properties developed in the previous study are valid for this modeling project. These properties include calibrated parameters, such as infiltration and erodibility coefficients, and measured soil size distributions. **Table 1.1** lists the premine and postmine soils data used during EASI modeling of CRA J1/N6 and N6 East Central.

1.3.2 Vegetation

Vegetative cover data representative of both pre- and postmine conditions in CRA J1/N6 and N6 East Central were supplied by PWCC. For the premine condition, land was characterized as being covered by sagebrush or pinon juniper. The spatial distribution of vegetative cover for the J1/N6 and N6 East Central CRA premine condition appears in **Figure 1.2**. Average cover properties for CRAs N1/N2 and J27 of the previous study and CRA J1/N6 and N6 East Central of the current study appear in **Table 1.2**. For the postmine condition, the reclaimed area was assigned the postmine cover type and the unmined area was assigned the same cover type as the premine condition. **Table 1.3** lists the pre- and postmine vegetative cover data used in the EASI model runs generated for the J1/N6 and N6 East Central CRA. Note that if a unit contained significant portions of both sagebrush and pinon juniper cover types, it was classified as half pinon juniper and half sagebrush.

1.3.3 Topography

Pre- and postmine topography was supplied by PWCC in the form of ArcGIS geodatabase. Basin delineations, hillslope delineations, subwatershed delineations, as well as areas, slopes, and lengths of all units of the study area were defined and calculated using ArcGIS software. **Figures 1.3 and 1.4** show the watershed delineation and numbers assigned to the basins used in the EASI model for the post- and premine conditions, respectively. Channel dimensions input to EASI were based on the topography supplied and limited field observations.

1.4 Methodology

Runoff and sediment yield in the semiarid western United States is largely governed by the occurrence of high-intensity, short-duration rainstorms of limited areal extent (Renard and Simaton 1975). Research has indicated that relatively few events may produce the greatest erosion (e.g., Hjelmfelt et al. 1986 reported that only 3 to 4% of rainfall events accounted for 50% of long-term sediment yields). Although there is perhaps a relatively limited physical basis for definition of an "average annual" runoff or sediment yield in a semiarid environment due to the extreme variability in response and importance of single infrequent events, such a term does provide a useful basis for long-term comparison between reclaimed and undisturbed conditions.

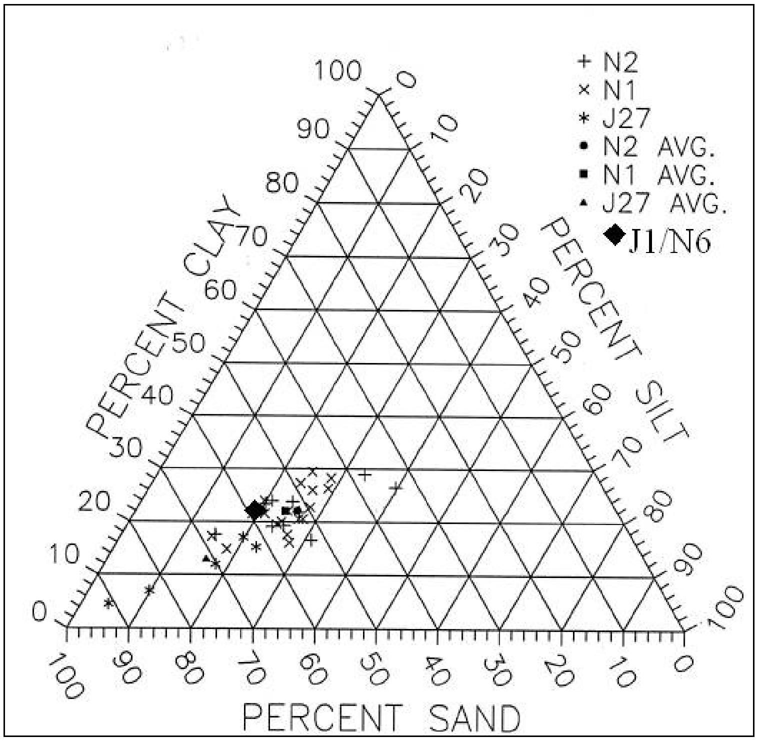

Figure 1.1. Reclaimed area soils trilinear graph.

Table 1.1. Soils Data.			
Condition	Premine	Postmine	Rock Chutes
Rainfall detachment	0.005	0.005	0
Overland flow detachment	0.44	0.44	0
Channel flow detachment	0.5	0.5	0
Initial soil moisture, %	70	70	70
Final soil moisture, %	90	90	90
Soil porosity, %	45	45	46
Temperature, *F	70	70	70
Hydraulic conductivity, in/hr	0.23	0.29	0.3
Capillary suction, in	3.7	2.6	2.6
	Particle Size Distribution (all conditions)		
	Size, mm	% Finer	
	0.001	0	
	0.004	18.0	
	0.016	27.4	
	0.062	36.6	
	0.125	56.2	
	0.250	64.3	
	0.500	72.4	
	1.000	80.5	
	2.000	88.6	
	4.000	92.4	
	16.000	100	

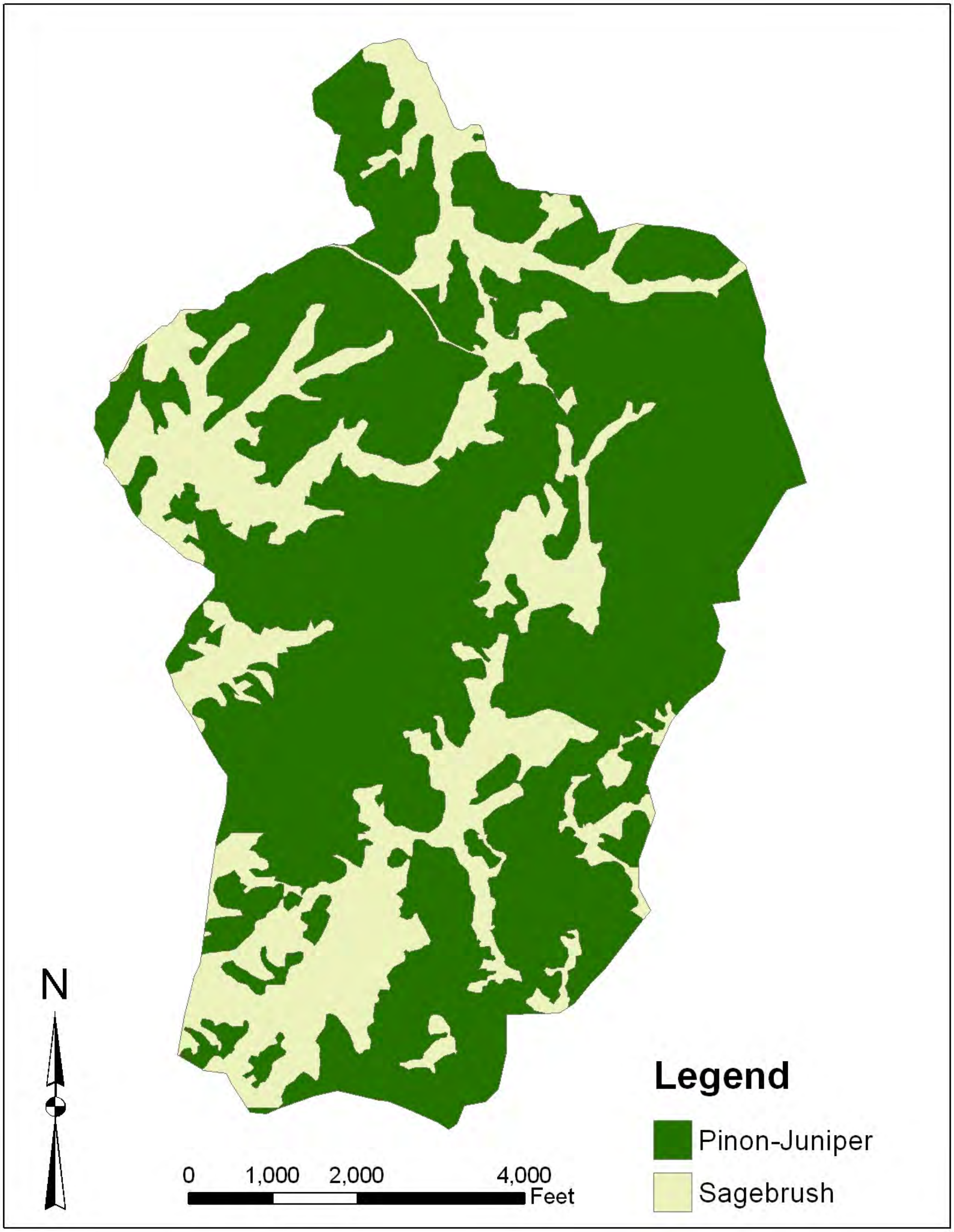

Figure 1.2. Vegetative cover for CRA J1/N6 and N6 East Central premine condition.

Table 1.2. Cover Sampling Data.

Area	Condition	Cover Type	Nonstratified Vegetation Cover (%)	Vegetation Canopy Cover (%)	Vegetation Ground Cover (%)	Litter* (%)	Rock (%)	Total Ground Cover (%)
N1/N2	Postmine	Postmine	25.6	1.4	24.2	13.6	4.2	41.9
J1/N6	Postmine	Postmine	20.6	0.3	20.4	21.6	4.2	46.2
N1/N2/J27	Premine	Pinon Juniper	32.7	31.1	3.0	44.0	19.7	66.7
J1/N6	Premine	Pinon Juniper	16.9	14.6	2.7	18.8	17.3	38.8
N1/N2	Premine	Sagebrush	25.1	16.0	10.3	25.3	18.1	53.7
J27	Premine	Sagebrush	30.6	9.7	22.0	24.0	1.6	47.6
J1/N6	Premine	Sagebrush	12.4	1.3	11.2	24.7	2.5	38.3

*Including standing dead litter

Table 1.3. Cover Data for J1/N6 and N6 East Central Watersheds.

Condition	Pinon Juniper	Sagebrush	Half Pinon Juniper-Half Sagebrush	Postmine
Canopy cover, %	14.6	1.3	8.0	0.3
Ground cover, %	38.8	38.3	38.5	46.2
Canopy storage, in	0.05	0.05	0.05	0.05
Ground storage, in	0.05	0.05	0.05	0.05
Depression storage, in	0.03	0.03	0.03	0.03
Impervious area, %	0	0	0	0
Manning n	0.07	0.07	0.07	0.05

To make comparisons between reclaimed lands and associated undisturbed lands at the Black Mesa Mining Complex on the basis of average annual sediment yield, a procedure was used that considers the importance of infrequent storm events in defining sediment yield in the semiarid west. First, however, the site-specific rainfall data available for the Black Mesa Mining Complex were used to evaluate the frequency and magnitude of the measured events relative to existing predictions for rainfall depth-duration (Miller et al. 1973). The analysis of the rainfall data was performed as part of a previous study of the N1/N2 and J27 CRAs (Resource Consultants and Engineers 1993).

Comparisons between runoff and sediment yield from undisturbed and reclaimed areas in CRA J1/N6 and N6 East Central were developed for specific modeling endpoints shown in Exhibits 1 and 2. Mining and reclamation activities did not exactly replicate the topography, drainage network, or drainage areas that existed prior to mining. Consequently, direct comparisons of total runoff and sediment yield cannot be made between undisturbed and reclaimed response at a given point in a watershed. Comparisons were made on the basis of unit rates of runoff (inches) and sediment yield (tons/acre) at the various modeling computation endpoints. Although the same disturbance boundary was used to define the extent of both pre- and postmine conditions, the topographic differences that resulted after mining and reclamation occurred in the J1/N6 and N6 East Central CRA dictated that some areas would be included or excluded from the modeling. The total area modeled for premine conditions is 1499.7 acres (Exhibit 2) and for postmine conditions is 1533.3 acres (Exhibit 1).

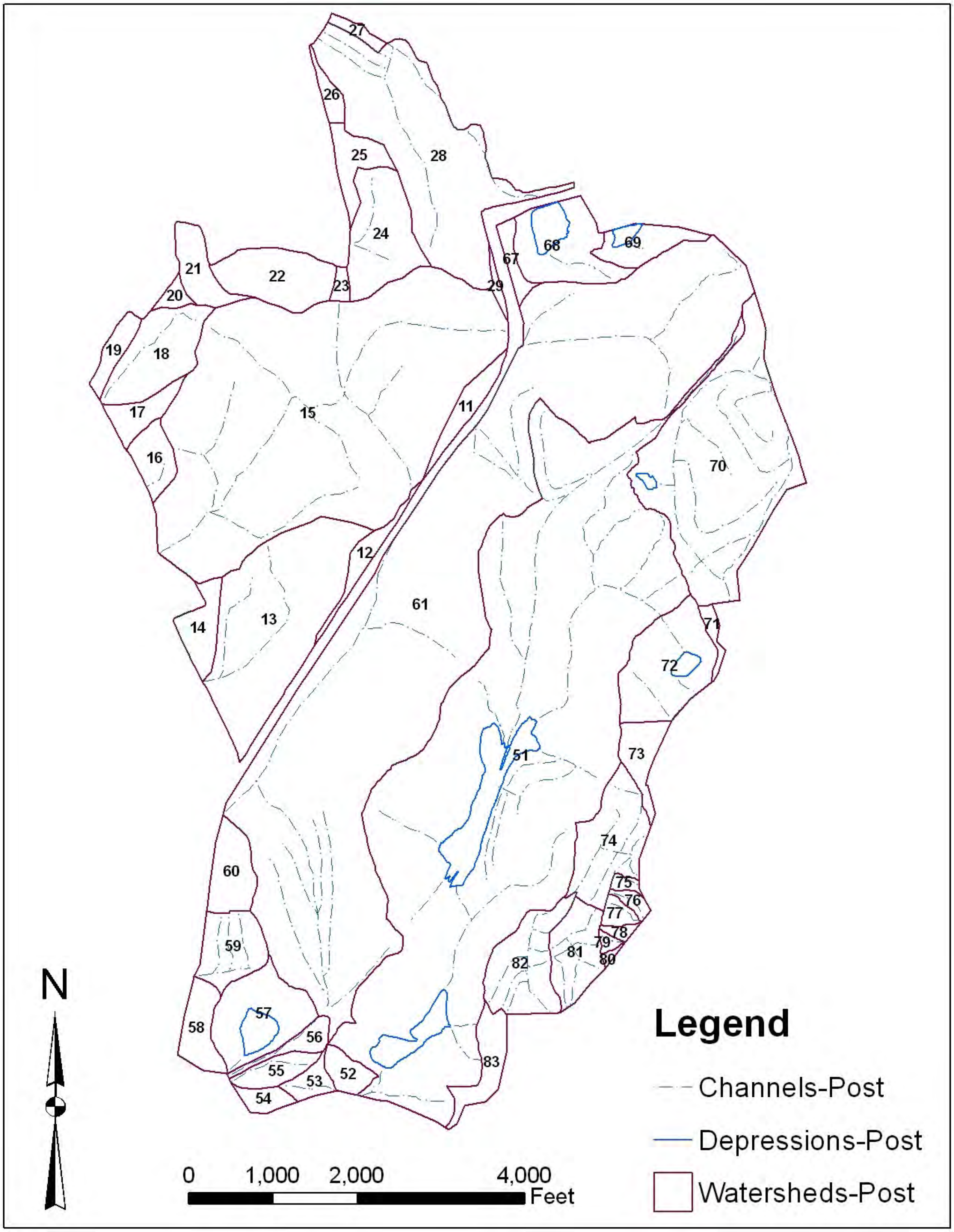

Figure 1.3. J1/N6 and N6 East Central postmine basins.

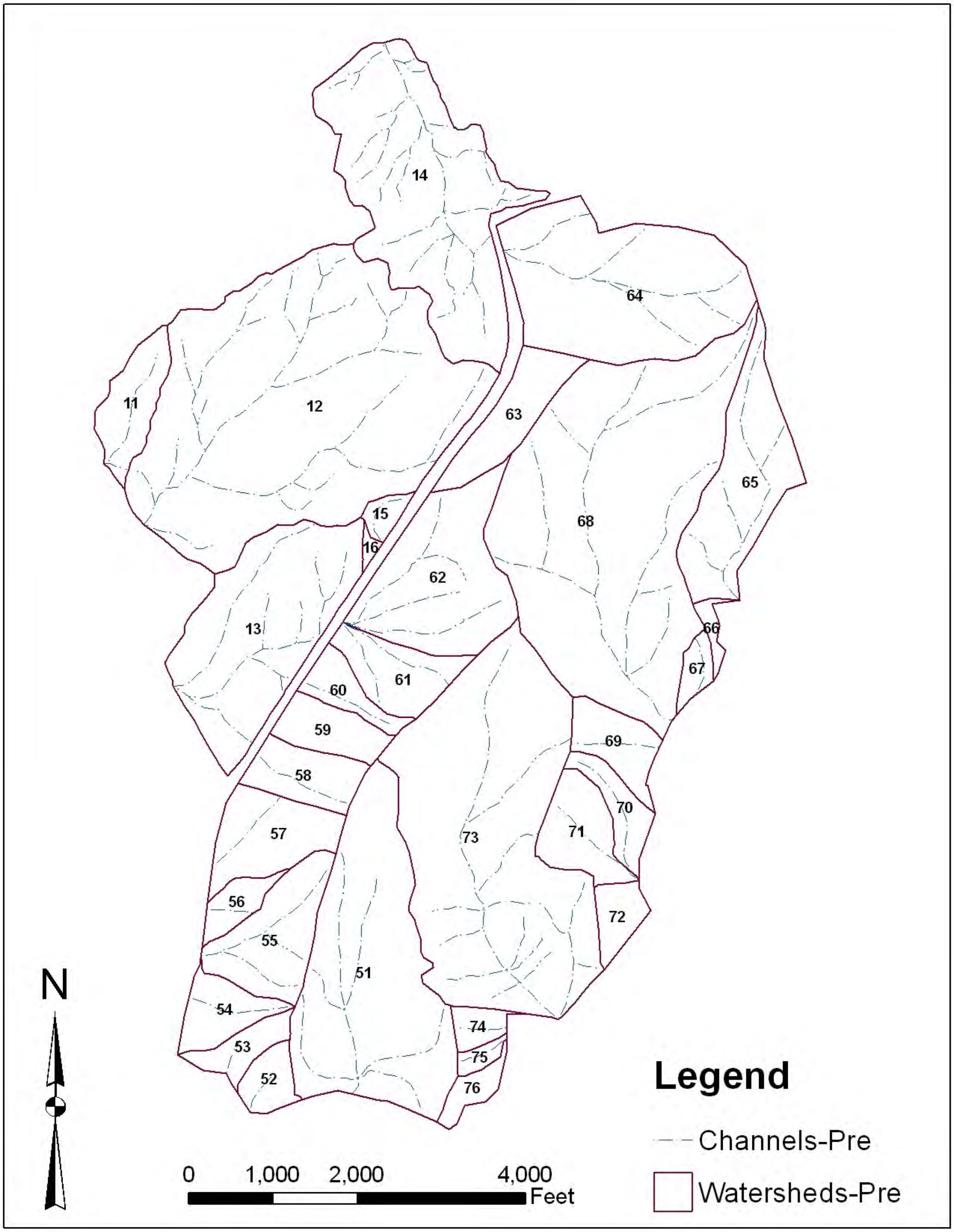

Figure 1.4. J1/N6 and N6 East Central premine basins.

1.4.1 Synthetic Rainfall

Synthetic storms of 2-, 5-, 10-, 25-, 50-, and 100-year return periods were used as input to the EASI model. Actual hyetographs were taken from the previous study (RCE 1993) and are based on both local data collection and the NOAA Atlas (Miller et al. 1973).

1.4.2 Computation of Average Runoff and Sediment Yield

The EASI model was used to evaluate runoff and sediment yield from a series of storm events having recurrence intervals of 2-, 5-, 10-, 25-, 50-, and 100 years. To define average annual conditions, the average annual runoff and sediment yield generated from storm events were computed using the commonly used equation of Lagasse et al. (1985).

1.5 Results

Figures 1.3 and 1.4 show the post- and premine basin delineations. Since the individual subareas differ in number, acreage and outlet locations, a direct comparison is not possible on a subarea basis. Therefore, the best way to compare the results is on an average basis for the CRA. **Table 1.4** shows pre- and postmine drainage area, runoff, and sediment yield for the J1/N6 and N6 East Central CRA. Runoff is defined as the total volume of water leaving the CRA on an average annual basis and, therefore, does not include water stored in depression areas and ponds. For the premine condition, this is equal to the amount of water that drains off the hillslopes and subwatersheds because there are no ponds or significant depressions. For the postmine condition, this is equal to the amount of hillslope runoff less the amount stored in ponds. Similarly, the sediment yield is the amount of eroded material that leaves the CRA on an average annual basis computed using the equation of Lagasse et al. (1985). The sediment yield is the production from the hillslope areas and erosion from the channels. The amount of erosion is the sediment yield from the hillslopes and subwatersheds only and does not include channel erosion, channel deposition or sediment trapped in ponds. Sediment yield can be greater or less than erosion, depending on the amount of channel erosion and the capacity of the channel network to convey sediment off the leasehold.

For the postmine condition, sediment yield is substantially less than the premine condition. Sediment yield is approximately one-third of the premine amount. Runoff is the same as the premine amount for the N6 East Central CRA, while runoff for postmine is much smaller than the premine amount for the J1/N6 CRA. The amount of hillslope runoff is virtually the same between pre- and postmine conditions and the difference between the runoff leaving the CRA is due to ponds and depressions storing water in the postmine condition. Hillslope and subwatershed erosion rates are lower for reclaimed (postmine) conditions due to more effective hydrologic cover and channel erosion control measures.

1.6 Discussion

Table 1.5 gives an overview of the geometric properties of the pre- and postmine topographies for the J1/N6 and N6 East Central CRA. The geometric properties for the postmine condition are similar to the premine condition.

Table 1.4. Average Runoff and Sediment Yield Results.

Area	Condition	Drainage Area (ac)	Runoff (in)	Sediment Yield (t/ac/yr)	Erosion (t/ac/yr)
J1/N6	Premine	1024.8	0.42	3.79	1.74
J1/N6	Postmine	1039.7	0.22	1.32	1.22
N6 East Central	Premine	474.9	0.42	3.68	0.80
N6 East Central	Postmine	493.6	0.42	1.61	0.65
Combined	Premine	1499.7	0.42	3.76	1.44
Combined	Postmine	1533.3	0.28	1.41	1.03

Table 1.5. Average Physical Properties of the J1/N6 and N6 East Central CRA.

	Premine	Postmine
Total Area (ac)	1499.7	1533.3
Total Channel Length (ft)	112,844	116,293
Mean Channel Slope	0.0563	0.0576
Drainage Density (mi/mi^2)	9.1	9.2
Mean Hillslope Length (ft)	269	320
Mean Hillslope Gradient	0.1171	0.1149

2. COMPARISONS WITH MEASURED SEDIMENT TRANSPORT

As discussed in Section 1, PWCC has monitored flow and sediment on the main channels, principal tributaries and small watersheds within the leasehold. These data, along with the runoff plots, were used to calibrate the EASI model soil erodibility and infiltration input variables. **Figures 2.1** and **2.2** show sediment transport and sediment concentration versus discharge for measured unmined (background), measured reclaimed, J1/N6 and N6 East Central's modeled unmined (premine) and modeled reclaimed (postmine) data. Although there is significant scatter shown in the data (as is expected with any sediment transport conditions), there are several conclusions that can be drawn from this data.

The open symbols in both figures depict measured data and whether the data were collected from reclaimed areas (the small watershed study) or from unmined or background surface water monitoring stations. The range of flows is generally greater for the background data but there is significant overlap between the two data sets between 0.1 cfs and 100 cfs. This is because the reclaimed data are from small watersheds and the unmined data are from channels draining larger basins. These data show the same trend for sediment transport and sediment concentration over the entire range of flows and very close agreement in the area of discharge overlap. This, in itself, is strong evidence that (1) the sediment yields are channel transport capacity limited, (2) overlap of model predictions for both pre- and postmine conditions with measured data strongly indicate that EASI model predictions are representative and reasonable, and (3) sediment yields from reclaimed areas will not be additive to yields on the receiving streams.

The closed symbols depict data from J1/N6 and N6 East Central's pre- and postmine EASI model runs. They represent data generated by EASI for both subwatersheds and channels for peak discharges resulting from 2-, 5-, 10-, 25-, 50- and 100-year storms. Using the peak flows from extreme events results in discharges that generally exceed 10 cfs. The trend of the model-derived data is similar and the ranges of concentration and sediment transport are similar to the measured data and between pre- and postmine conditions.

The sediment discharge plot (Figure 2.1) shows a stronger trend because it is plotting discharge (sediment) against discharge (flow). This is expected because the sediment discharge does depend on flow discharge. The concentration plot (Figure 2.2) shows the two separate variables and, therefore, a less significant trend. PWCC believes that data measurement may have some influence on the scatter (outliers were removed), but the process variability is probably the major influence. The majority of the data, however, fall in a group centered on 100 cfs and 100,000 mg/l, both in the observed data and in the model results. These plots support the use of the EASI model, the results of the modeling, the conclusion that sediment yields from reclaimed areas are not additive to receiving stream sediment loads, and that sediment impacts to the prevailing hydrologic balance have been minimized.

From Figures 2.1 and 2.2 it is apparent that sediment loads and concentrations are dependent on the channel sediment transport capacity for both pre- and postmine conditions. Channel sources of sediment in this arid environment are virtually unlimited. Therefore, channel transport capacity and channel derived sediment limits and governs sediment yields from the small tributaries, large channels and the CRA as a whole. The similarity of sediment discharge (or concentration) between pre- and postmine conditions appears to be inconsistent with the lower rates of sediment yield shown in Table 1.4.

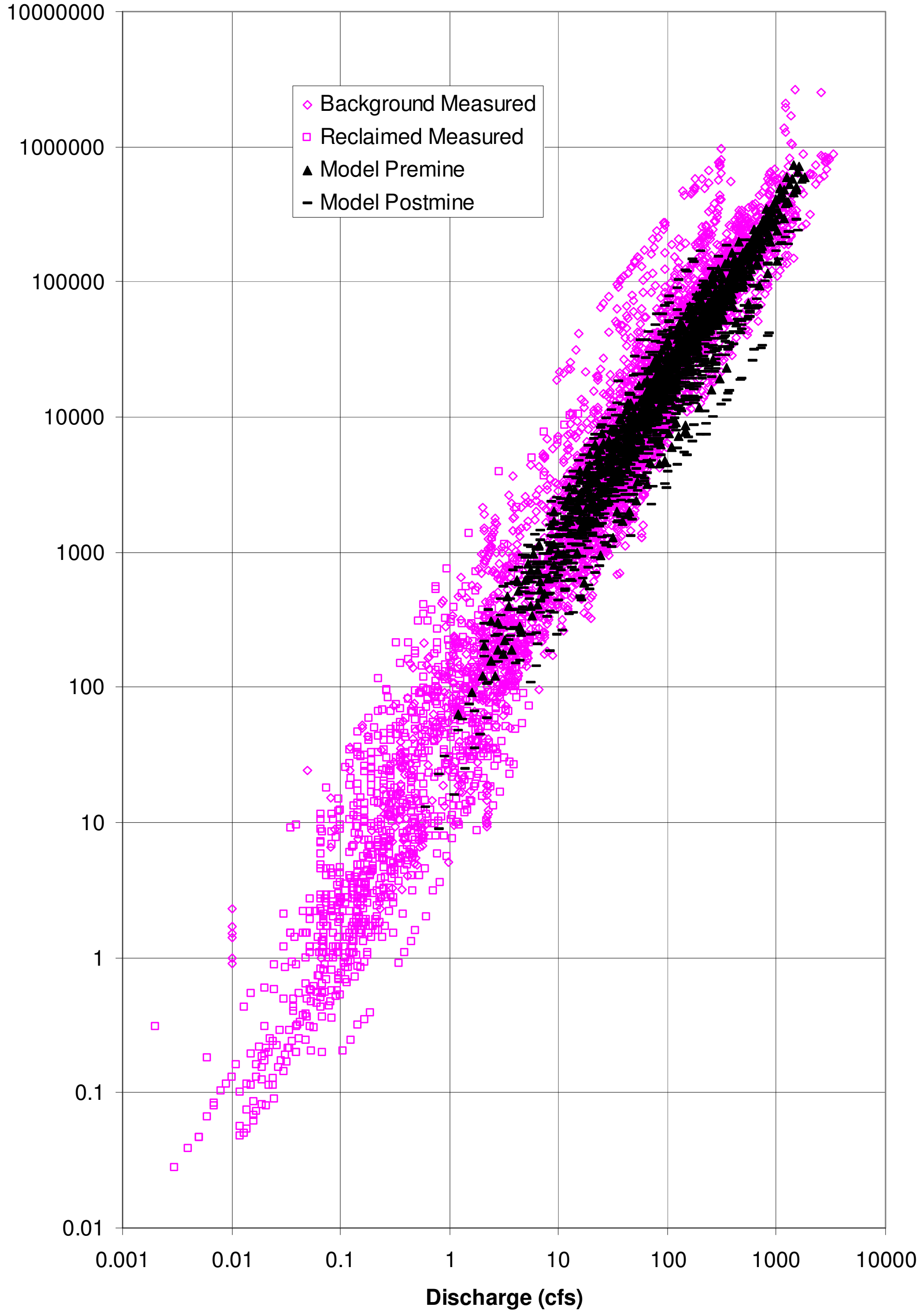

Figure 2.1. Observed and modeled sediment discharge and water discharge.

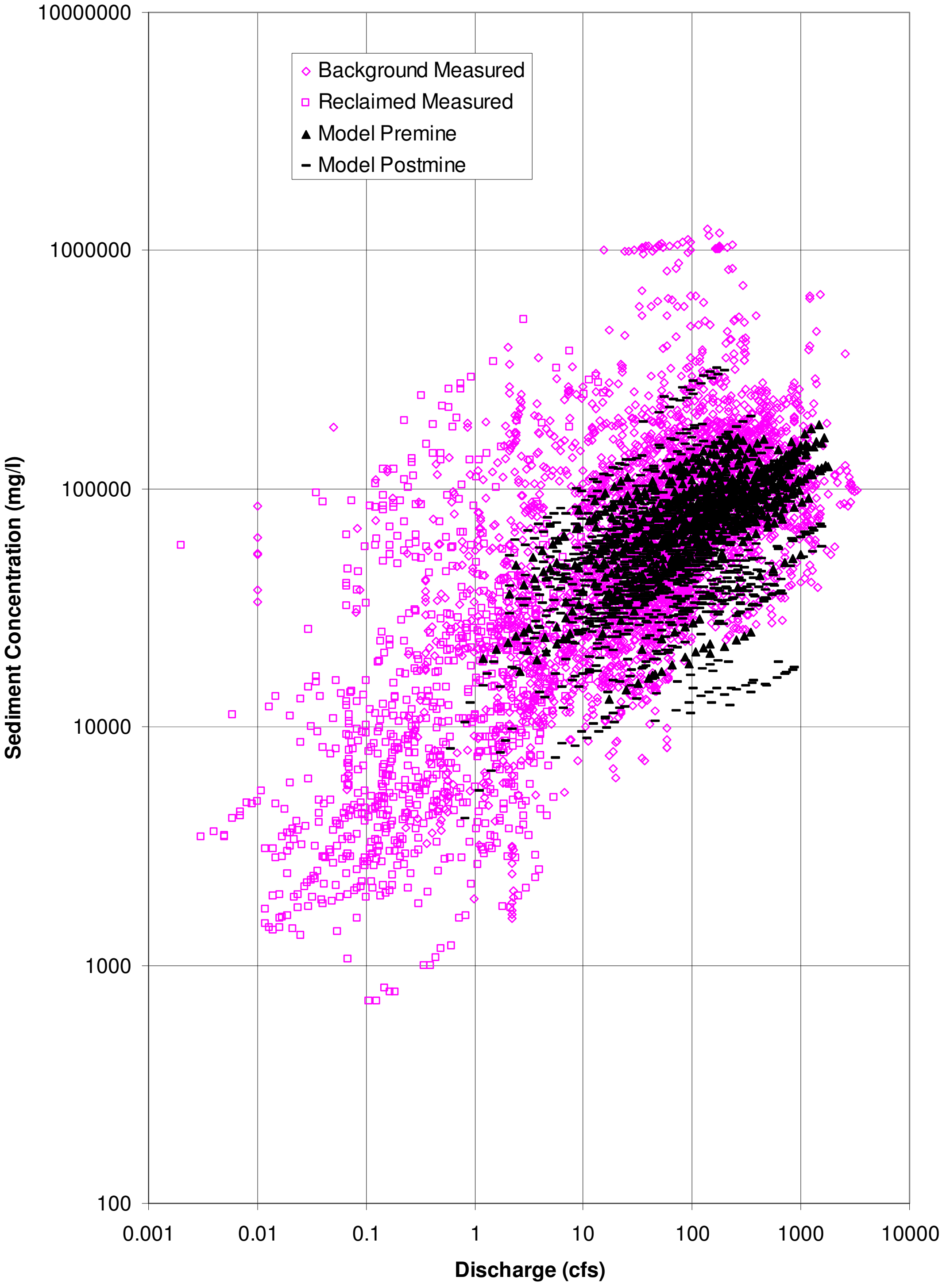

Figure 2.2. Observed versus modeled sediment concentration and discharge.

However, the sediment yield shown in Table 1.4 is the amount of sediment leaving the CRA whereas the sediment discharge shown in Figure 2.1 is the peak rate of sediment in transport occurring in any channel on the CRA, whether the channel is located upstream or downstream of a pond. Therefore, with or without the ponds trapping sediment or storing water, the mine reclamation is not contributing additional sediment to the receiving streams and sediment impacts to the prevailing hydrologic balance have been minimized.

Smith and Best (2000) analyzed the measured data (background and reclaimed) shown in Figure 2.1 to develop an approach that can be used to determine if channels in reclaimed areas have similar sediment transport characteristics as background channels. The method that they used was to develop Sen lines (Sen 1968) and confidence intervals around the data. The slope of the Sen line is a non-parametric statistic computed as the median slope of all possible slopes determined from pairing all the data points. The Sen line is drawn through the median coordinate of the data. Smith and Best first showed that the large channel flume data (background) and the small watershed background data could be combined. They concluded that since the data from one data set fall within the Sen line bounds of the other data set then the two data sets are merely extensions of each other and could be combined. Also, because the main channel and background small watershed site data could be combined, it indicated there is an unlimited supply of sediment and the channels are conveying sediment at (or near) capacity. The Sen line and bounds are shown with the background measured data in **Figure 2.3**.

They then plotted the reclaimed measured data (**Figure 2.4**) with the Sen line and bounds from the background data to show that the reclaimed data have the same characteristics even though the flow range of the measurements is lower. The data indicate that channel flows in this environment achieve the sediment transport capacity of the channel, whether in reclaimed or background conditions.

Using the same approach with the modeled data generated for the CRA, **Figures 2.5 and 2.6** show the pre- and postmine computed sediment transport rates with the Sen lines and bounds. One difference between the plots is that the measured data occur throughout the flow hydrograph whereas the modeled data are tabulated at the peak of the simulation flow hydrograph. The premine data plot (Figure 2.5) shows the data grouped densely around the Sen line and well within the bounds. The postmine data (Figure 2.6) also plot closely around the Sen line and well within bounds. On these graphs data plotting below the Sen line indicate that there is less sediment in transport for a given discharge.

Several conclusions can be drawn from these data plots: (1) EASI model well replicates erosion and sediment transport processes at the mine site for background and reclaimed conditions, (2) all data show similar trends and are within the same bounds, (3) data trends indicate that channels are transporting sediment at or near capacity, and (4) amounts of sediment leaving the CRA for postmine conditions are similar to premine conditions and within the range expected for the background conditions. Therefore, the overall conclusion is that the postmine reclaimed condition in the J1/N6 and N6 East Central CRA is not contributing additional suspended solids to receiving streams, and related impacts to the hydrologic balance have been minimized.

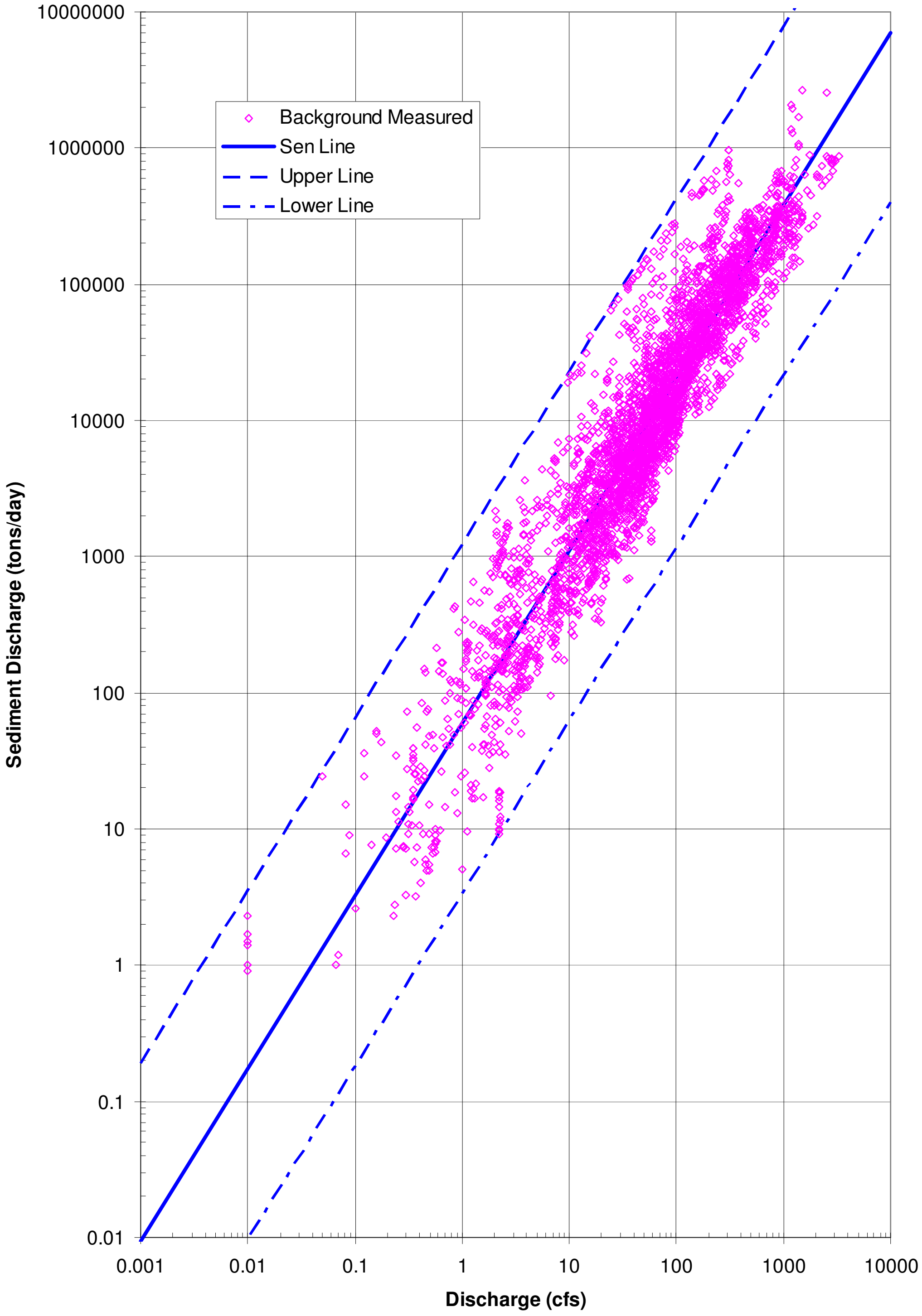

Figure 2.3. Background measured sediment and water discharge.

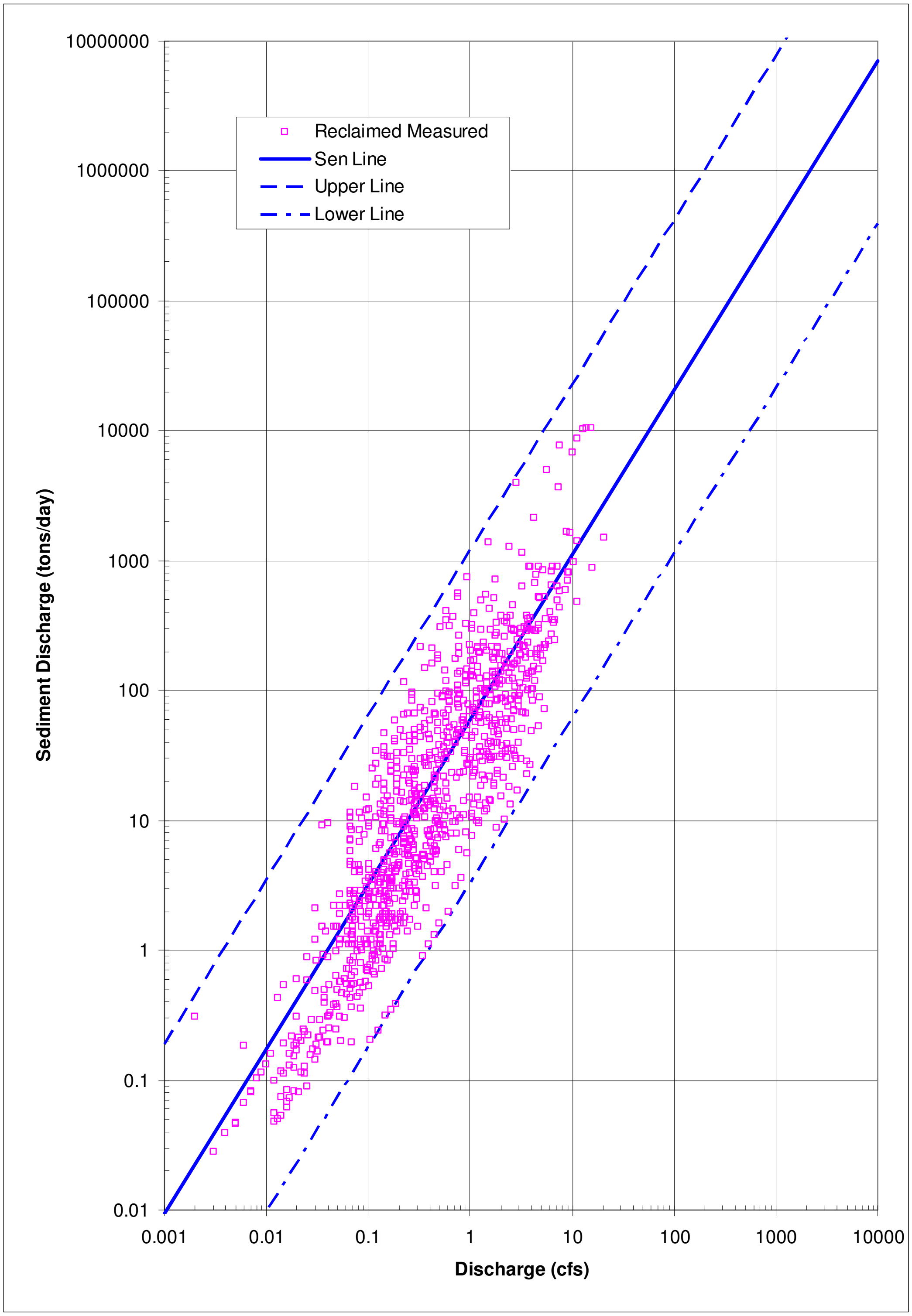

Figure 2.4. Reclaimed measured sediment and water discharge.

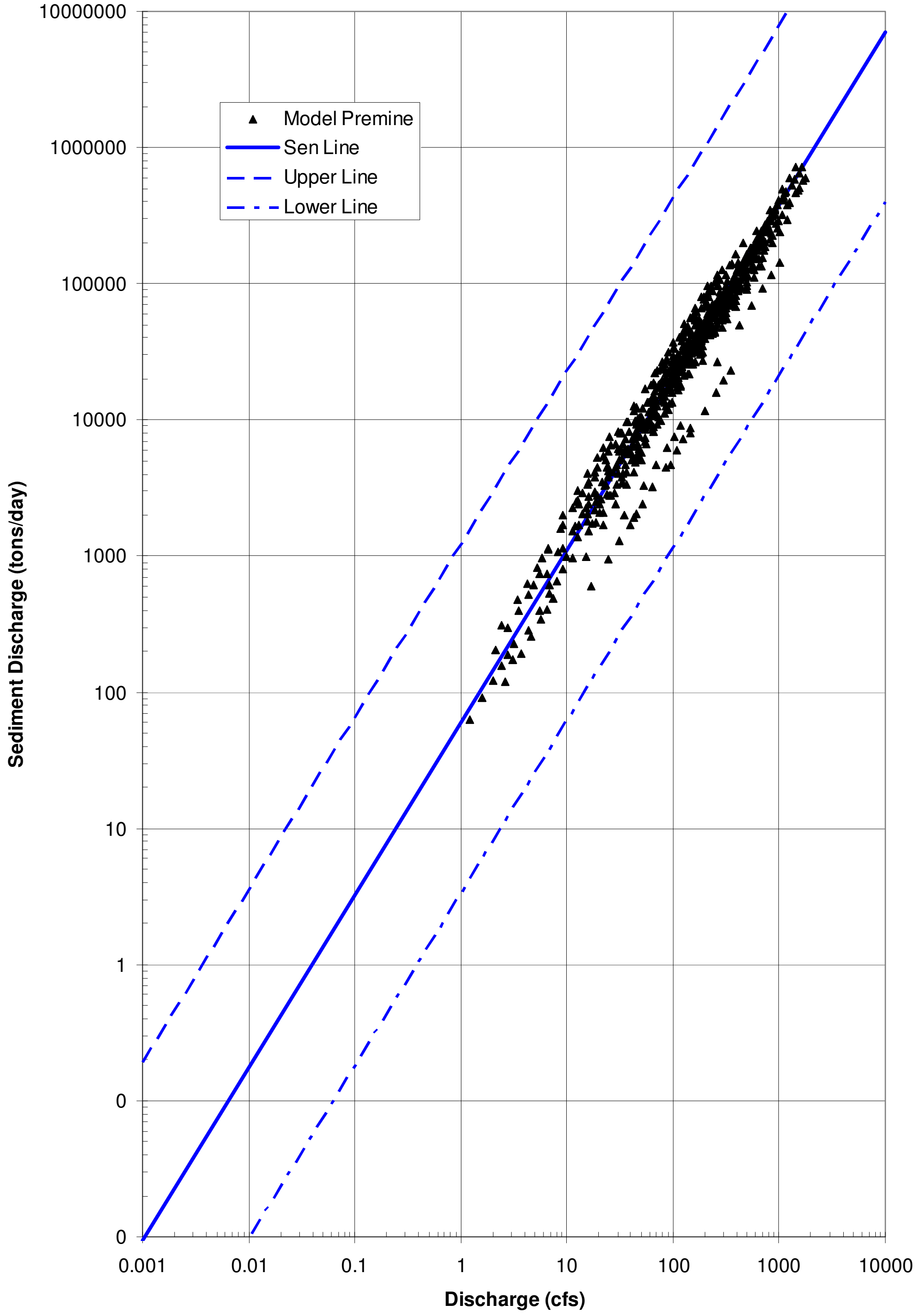

Figure 2.5. Modeled premine sediment and water discharge for J1/N6 and N6 East Central.

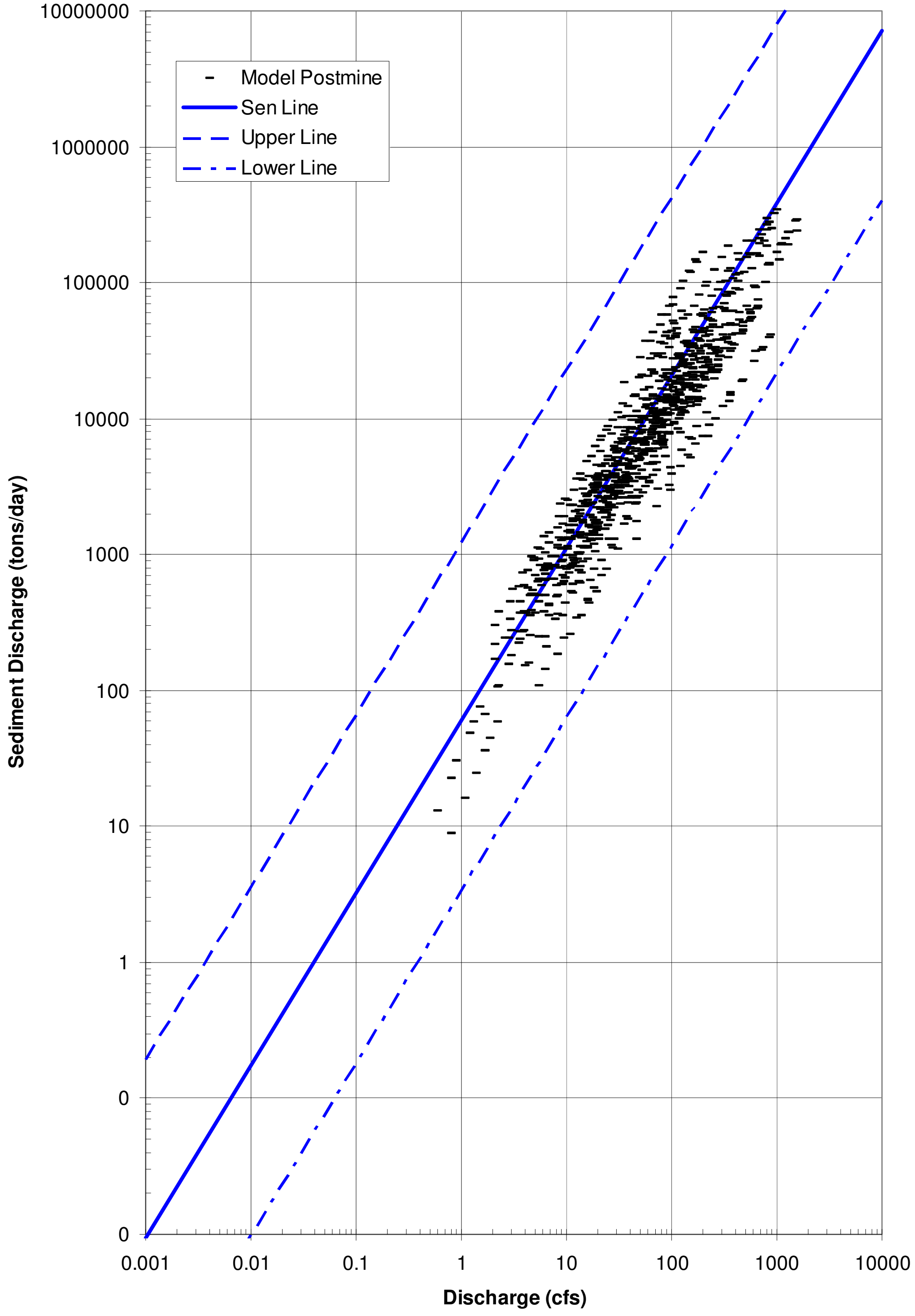

Figure 2.6. Modeled postmine sediment and water discharge for J1/N6 and N6 East Central.

3. REFERENCES

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EXHIBIT 1

Postmine Topography

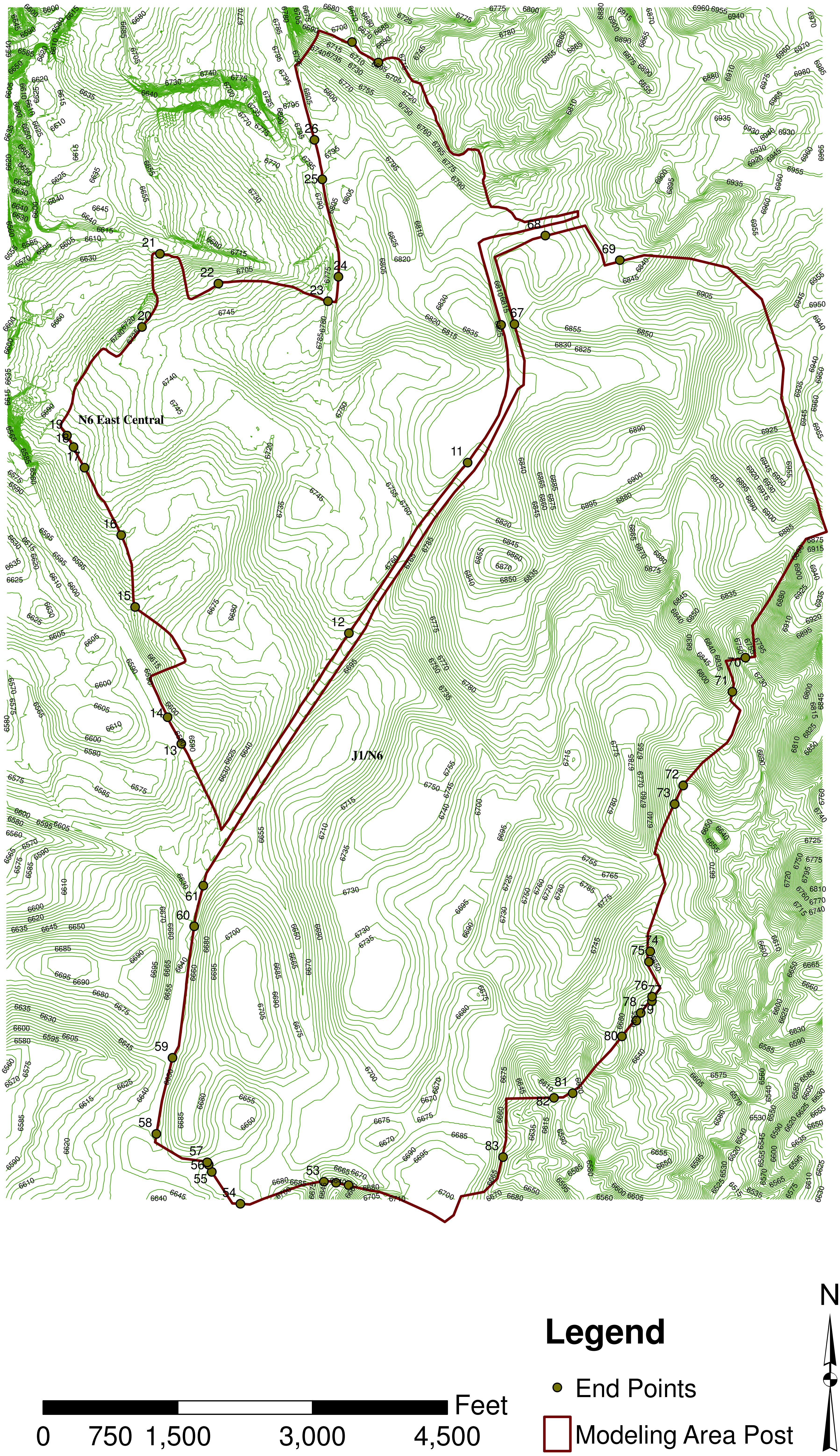

Exhibit 1. Postmine Topography
(5 foot contour)

EXHIBIT 2

Premine Topography

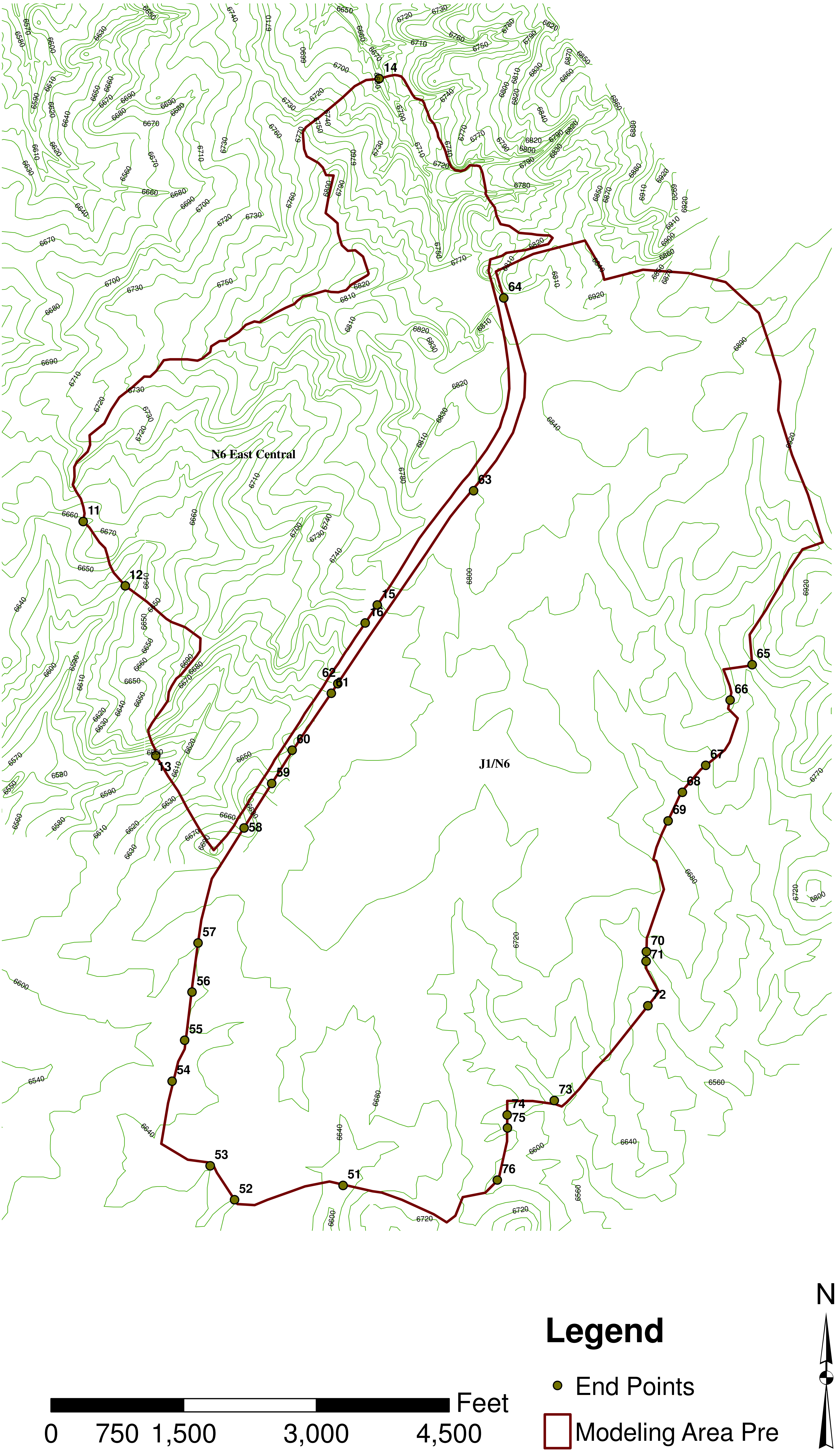

Exhibit 2. Premine Topography (10 & 40 foot contour)

Attachment 3-5b

Surface Water Modeling of the Reclaimed Ponds J16-E and J16-F Watershed Area at Kayenta Mine

SURFACE WATER MODELING OF THE RECLAIMED J16-E AND J16-F WATERSHED AREA AT KAYENTA MINE

Prepared for

Peabody Western Coal Co.
Highway 160, Navajo Route 41
Kayenta, Arizona 86033

AYRES
ASSOCIATES

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Ayres Project No. 32-1304.00
PEAB8-TX.DOC

August 2008

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1. RECLAIMED PARCEL MODELING

1.1 Introduction

The objective defined by PWCC for this project is to use a previously calibrated and validated runoff and erosion model (EASI, Zevenbergen et al. 1990; WET 1990) for the Black Mesa and Kayenta Mines to predict mean annual runoff and sediment yields from the reclaimed J16-E and J16-F watersheds. This objective included computation of runoff and sediment yields under premine conditions for the same area. All soils and rainfall input to the model are to be taken from models calibrated in the previous study (RCE 1993). The input variables that were calibrated to the mine areas and used in this study include soil infiltration parameters, erodibility parameters, and the grain size distribution. Parameters that are specific to this study are vegetative canopy and ground cover percentages from data collected on site.

The model calibration was conducted in a previous study (RCE 1993) using data obtained from instrumented watersheds and small hillslope plots collected under natural rainfall conditions. For a detailed discussion of data collection and model calibration, please refer to the previous study (RCE 1993).

1.2 Background

The J16-E and J16-F Watershed Area (WA) that is the focus of this project was reclaimed between 1984 and 2002. The fundamental purpose of this study was to quantify the expected behavior and hydrologic response of the reclaimed areas above each pond relative to the conditions that existed prior to the occurrence of mining activities.

Runoff and sediment yield response from the reclaimed lands should be managed by implementing Best Management Practices (BMP's) in conjunction with an OSM approved sediment control plan in order to not adversely impact the prevailing hydrologic balance and to limit additional contributions of suspended sediment to streamflow or runoff outside the mine permit areas. BMP's include regrading, replacing salvaged topsoil, revegetation, and other controls such as riprapped channel bottoms, check dams, and where practicable, contour terraces. The natural watersheds on the mesa contribute significant quantities of sediment to the channel system. It is expected that the postmine condition will also produce comparable amounts of sediment without adverse impact on the hydrologic balance.

This section describes the data and procedures used to evaluate the J16 WA. This area was modeled to determine the average annual hydrologic response following the completion of reclamation activities taking into account BMP's implemented as part of the reclamation process. Infiltration, runoff, and erosion processes from both hillslopes and channels within the J16 WA were modeled using EASI. Results were determined for concentration points at the outlets of the reclaimed watersheds, which correspond to the embankments associated with Ponds J16-E and J16-F. The locations of these points are shown in **Exhibit 1**. Modeling was also conducted to determine hydrologic response under premine conditions based on the topography, soils, cover, and other conditions that typified the undisturbed watersheds draining to each concentration point. **Exhibit 2** shows the modeling endpoints for the premine J16 WA.

1.3 Data

1.3.1 Soils

Soils data used for the current study (J16 WA) were based on data developed from the calibration of models used in the previous study for Coal Resource Areas (CRAs) N1/N2 and J27 (RCE 1993). The composition of postmine soil in the current study is depicted along with the composition of postmine soils from the previous study in **Figure 1.1**. This figure shows that the soil composition of WA J16 is very similar to soils evaluated during model calibration. Therefore, the soil properties developed in the previous study are valid for this modeling project. These properties include calibrated parameters, such as infiltration and erodibility coefficients, and measured soil size distributions. **Table 1.1** lists the premine and postmine soils data used during EASI modeling of WA J16.

1.3.2 Vegetation

Vegetative cover data representative of both pre- and postmine conditions in WA J16 were supplied by PWCC. For the premine condition, land was characterized as being covered by sagebrush or pinon juniper. The spatial distribution of vegetative cover for the J16 WA premine condition appears in **Figure 1.2**. Average cover properties for CRAs N1/N2 and J27 of the previous study and WA J16 of the current study appear in **Table 1.2**. For the postmine condition, the reclaimed area was assigned the postmine cover type and the unmined area was assigned the same cover type as the premine condition. **Table 1.3** lists the pre- and postmine vegetative cover data used in the EASI model runs generated for the J16 WA. Note that if a unit contained significant portions of both sagebrush and pinon juniper cover types, it was classified as half pinon juniper and half sagebrush.

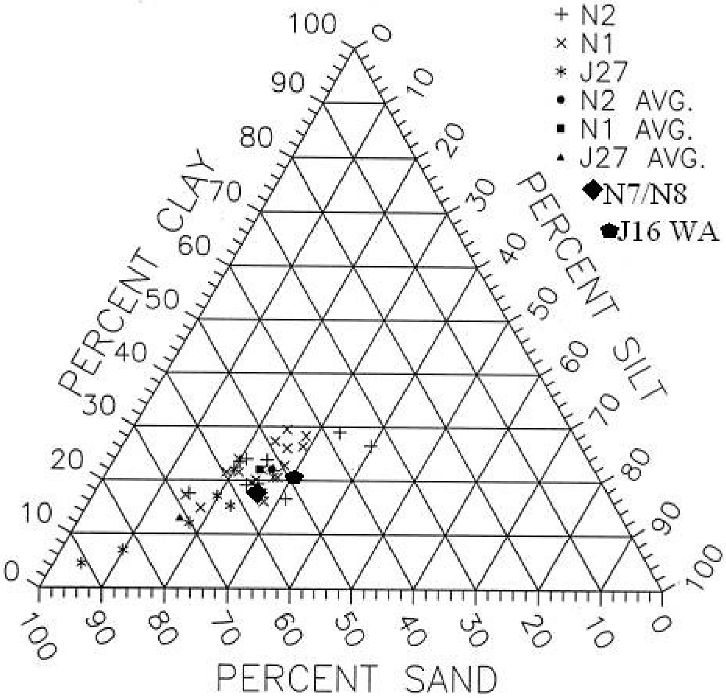

Figure 1.1. Reclaimed area soils trilinear graph.

Table 1.1. Soils Data.

Condition	Premine	Postmine	Rock Chutes
Rainfall detachment	0.005	0.005	0
Overland flow detachment	0.44	0.44	0
Channel flow detachment	0.5	0.5	0
Initial soil moisture, %	70	70	70
Final soil moisture, %	90	90	90
Soil porosity, %	45	45	46
Temperature, *F	70	70	70
Hydraulic conductivity, in/hr	0.23	0.29	0.3
Capillary suction, in	3.7	2.6	2.6
	Particle Size Distribution (all conditions)		
	Size, mm	% Finer	
	0.001	0	
	0.004	18.0	
	0.016	27.4	
	0.062	36.6	
	0.125	56.2	
	0.250	64.3	
	0.500	72.4	
	1.000	80.5	
	2.000	88.6	
	4.000	92.4	
	16.000	100	

1.3.3 Topography

Pre- and postmine topography was supplied by PWCC in the form of ArcGIS geodatabase. Basin delineations, hillslope delineations, subwatershed delineations, as well as areas, slopes, and lengths of all units of the study area were defined and calculated using ArcGIS software. **Figures 1.3 and 1.4** show the watershed delineation and numbers assigned to the basins used in the EASI model for the post- and premine conditions, respectively. Channel dimensions input to EASI were based on the topography supplied and limited field observations.

1.4 Methodology

Runoff and sediment yield in the semiarid western United States is largely governed by the occurrence of high-intensity, short-duration rainstorms of limited areal extent (Renard and Simaton 1975). Research has indicated that relatively few events may produce the greatest erosion (e.g., Hjelmfelt et al. 1986 reported that only 3 to 4% of rainfall events accounted for 50% of long-term sediment yields). Although there is perhaps a relatively limited physical basis for definition of an "average annual" runoff or sediment yield in a semiarid environment due to the extreme variability in response and importance of single infrequent events, such a term does provide a useful basis for long-term comparison between reclaimed and undisturbed conditions.

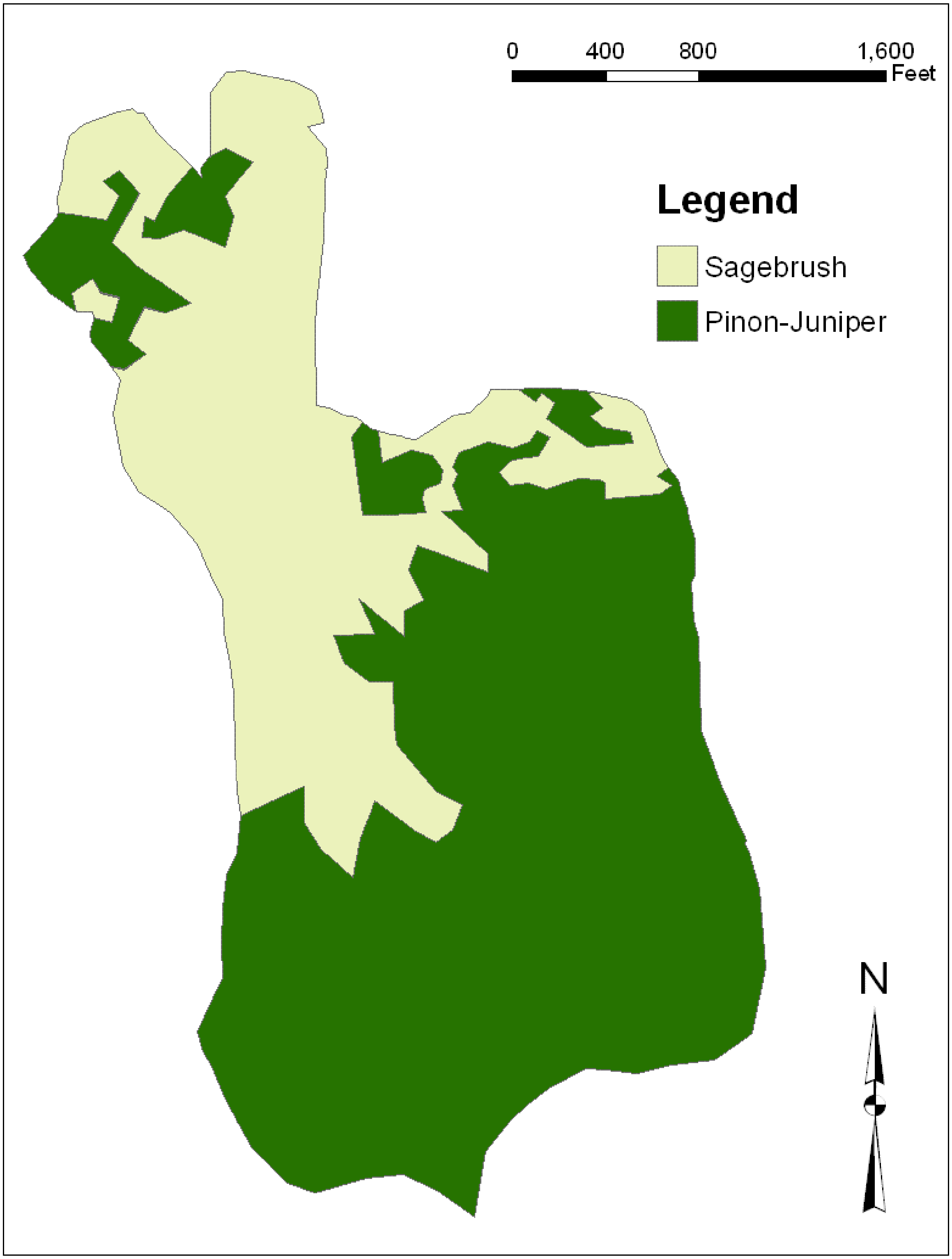

Figure 1.2. Spatial distribution of vegetative cover types for WA J16 premine condition.

Table 1.2. Cover Sampling Data.

Area	Condition	Cover Type	Nonstratified Vegetation Cover (%)	Vegetation Canopy Cover (%)	Vegetation Ground Cover (%)	Litter* (%)	Rock (%)	Total Ground Cover (%)
N1/N2	Postmine	Postmine	25.6	1.4	24.2	13.6	4.2	41.9
J16 WA	Postmine	Postmine		0.3	34.7	20.2	6.1	61.0
N1/N2/J27	Premine	Pinon Juniper	32.7	31.1	3.0	44.0	19.7	66.7
J16 WA	Premine	Pinon Juniper		16.8	3.9	28.8	16.7	49.3
N1/N2	Premine	Sagebrush	25.1	16.0	10.3	25.3	18.1	53.7
J27	Premine	Sagebrush	30.6	9.7	22.0	24.0	1.6	47.6
J16 WA	Premine	Sagebrush		1.7	15.5	30.6	1.7	47.8

*Including standing dead litter

Table 1.3. Cover Data for J16-E and J16-F Watersheds.

Condition	Pinon Juniper	Sagebrush	Half Pinon Juniper-Half Sagebrush	Postmine
Canopy cover, %	16.8	1.7	9.3	0.3
Ground cover, %	49.3	47.8	48.5	61
Canopy storage, in	0.05	0.05	0.05	0.05
Ground storage, in	0.05	0.05	0.05	0.05
Depression storage, in	0.03	0.03	0.03	0.03
Impervious area, %	0	0	0	0
Manning n	0.07	0.07	0.07	0.05

To make comparisons between reclaimed lands and associated undisturbed lands at the Black Mesa Mining Complex on the basis of average annual sediment yield, a procedure was used that considers the importance of infrequent storm events in defining sediment yield in the semiarid west. First, however, the site-specific rainfall data available for the Black Mesa Mining Complex were used to evaluate the frequency and magnitude of the measured events relative to existing predictions for rainfall depth-duration (Miller et al. 1973). The analysis of the rainfall data was performed as part of a previous study of the N1/N2 and J27 CRAs (Resource Consultants and Engineers 1993).

Comparisons between runoff and sediment yield from undisturbed and reclaimed areas in WA J16 were developed for specific modeling endpoints shown in Exhibits 1 and 2. Mining and reclamation activities did not exactly replicate the topography, drainage network, or drainage areas that existed prior to mining. Consequently, direct comparisons of total runoff and sediment yield cannot be made between undisturbed and reclaimed response at a given point in a watershed. Comparisons were made on the basis of unit rates of runoff (inches) and sediment yield (tons/acre) at the various modeling computation endpoints. Although the same disturbance boundary was used to model extents for both pre- and postmine conditions, the topographic differences that resulted after mining and reclamation occurred in the J16 WA dictated that some small areas would be included or excluded from the modeling. The total area modeled (combined area for both J16-E and J16-F watersheds) for premine conditions is 179.2 acres and for postmine conditions is 148.5 acres. The difference in area results from the sediment ponds in postmine conditions and the extension of J16F's premine basin. The area bounded by the disturbance limits identified by PWCC as shown in Exhibit 1 is 150.2 acres.

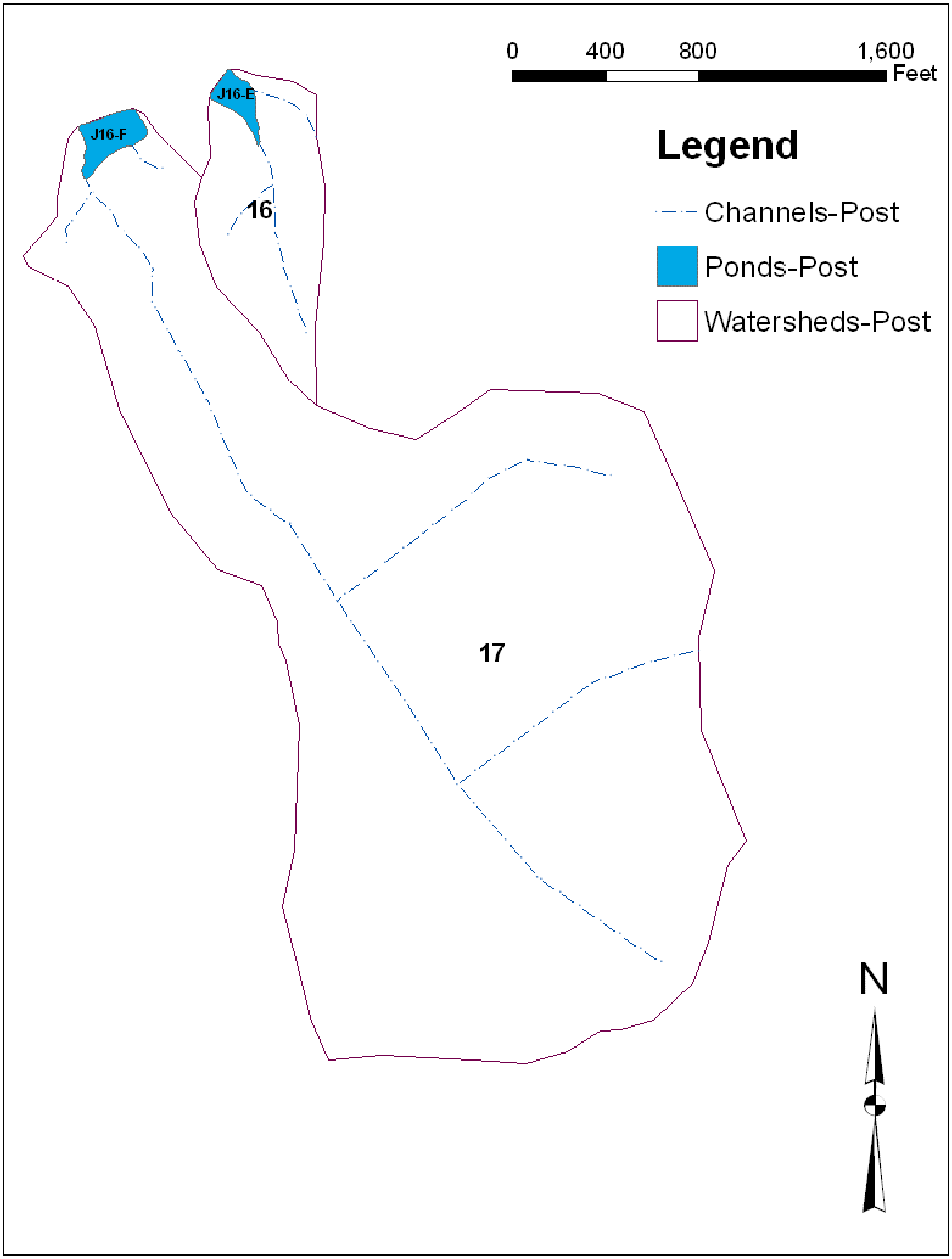

Figure 1.3. J16-E and J16-F postmine basins.

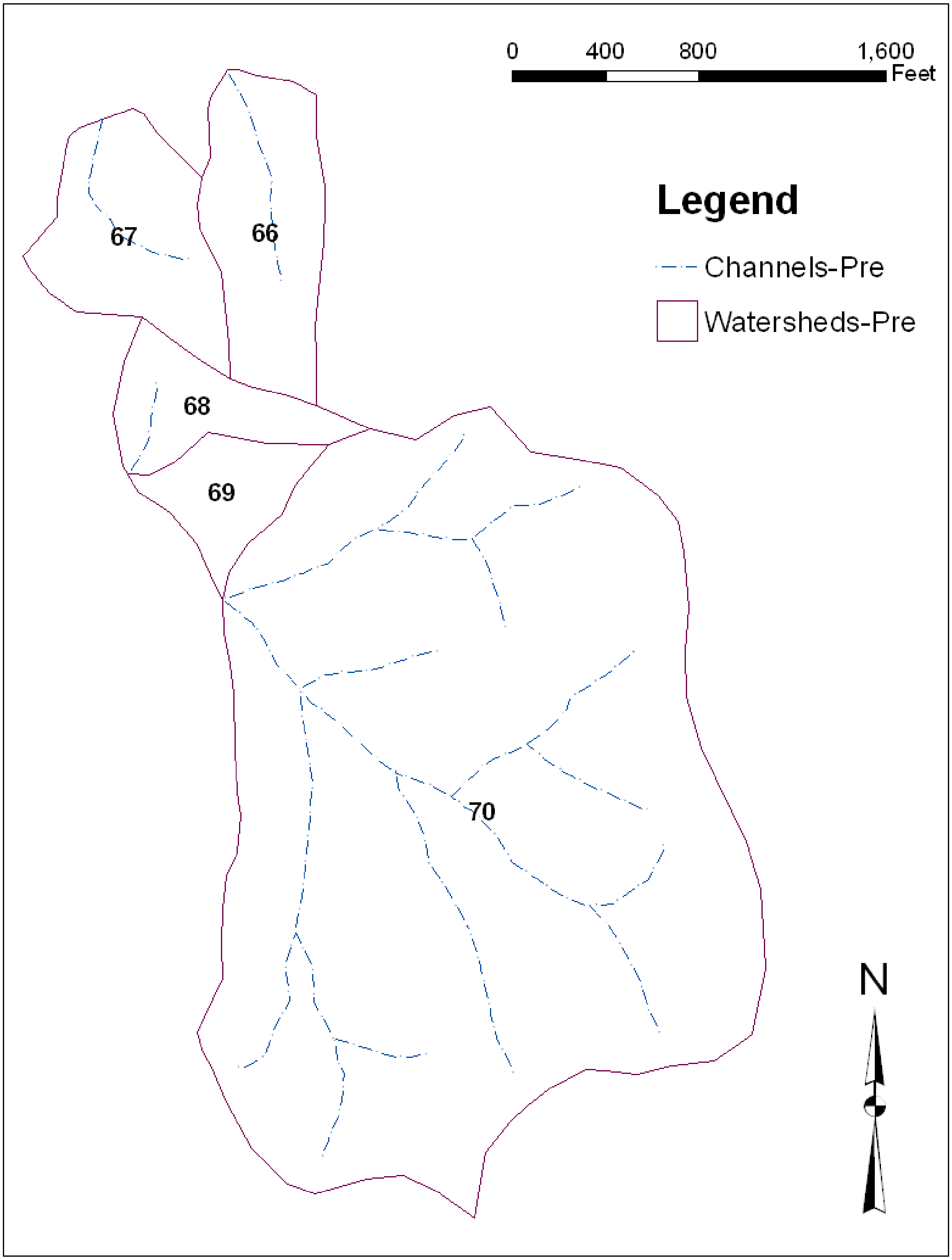

Figure 1.4. J16-E and J16-F premine basins.

1.4.1 Synthetic Rainfall

Synthetic storms of 2-, 5-, 10-, 25-, 50-, and 100-year return periods were used as input to the EASI model. Actual hyetographs were taken from the previous study (RCE 1993) and are based on both local data collection and the NOAA Atlas (Miller et al. 1973).

1.4.2 Computation of Average Runoff and Sediment Yield

The EASI model was used to evaluate runoff and sediment yield from a series of storm events having recurrence intervals of 2-, 5-, 10-, 25-, 50-, and 100 years. To define average annual conditions, the average annual runoff and sediment yield generated from storm events were computed using the commonly used equation of Lagasse et al. (1985).

1.5 Results

Figures 1.3 and 1.4 show the post- and premine basin delineations. Since the individual subareas differ in number, acreage and outlet locations, a direct comparison is not possible on a subarea basis. Therefore, the best way to compare the results is on an average basis for the WA. **Table 1.4** shows pre- and postmine drainage area, runoff, and sediment yield for the J16 WA. Runoff is defined as the total volume of water leaving the WA on an average annual basis and, therefore, does not include water stored in depression areas and ponds. For the premine condition, this is equal to the amount of water that drains off the hillslopes and subwatersheds because there are no ponds or significant depressions. For the postmine condition, this is equal to the amount of hillslope runoff less the amount stored in ponds. No ponds or significant depressions exist within the reclaimed J16 WA that was modeled. Similarly, the sediment yield is the amount of eroded material that leaves the WA on an average annual basis computed using the equation of Lagasse et al. (1985). The sediment yield is the production from the hillslope areas and erosion from the channels. The amount of erosion is the sediment yield from the hillslopes and subwatersheds only and does not include channel erosion, channel deposition or sediment trapped in ponds. Sediment yield can be greater or less than erosion, depending on the amount of channel erosion and the capacity of the channel network to convey sediment off the leasehold.

Table 1.4. Average Runoff and Sediment Yield Results.

Area	Condition	Drainage Area (ac)	Runoff (in)	Sediment Yield (t/ac/yr)
J16 WA	Premine	179.2	0.42	2.28
J16 WA	Postmine	148.5	0.42	1.14
J16-E	Premine	13.8	0.42	1.50
J16-E	Postmine	11.9	0.42	1.07
J16-F	Premine	165.4	0.42	2.34
J16-F	Postmine	136.6	0.42	1.15

For the postmine condition, the overall sediment yield is less than those in the premine condition. Sediment yield is approximately one-half of the premine amount, and runoff is the same as the premine amount. The reduction of sediment yield is primarily due to the channel erosion control measures (BMP’s) for the postmine condition.

Table 1.4 also shows pre- and postmine drainage area, runoff, and sediment yield for two individual watersheds (J16-E and J16-F) within the J16 WA. Modeling results of individual watersheds are similar to the overall J16 WA.

1.6 Discussion

Table 1.5 gives an overview of the geometric properties of the pre- and postmine disturbed areas. Premine hillslopes are generally longer than postmine hillslopes, and postmine channels are not as steep as premine channels. The drainage density of the postmine condition is smaller than that of the premine condition, because the postmine topography has simple geometric characteristics and the premine topography is highly dissected.

Table 1.5. Average Physical Properties of the J16 WA.

	Premine	Postmine
Total Area (ac)	179.2	148.5
Total Channel Length (ft)	14773	8715
Mean Channel Slope	0.0733	0.0594
Drainage Density (mi/mi^2)	10.0	7.1
Mean Hillslope Length (ft)	257	248
Mean Hillslope Gradient	0.1354	0.0702

2. COMPARISONS WITH MEASURED SEDIMENT TRANSPORT

As discussed in Section 1, PWCC has monitored flow and sediment on the main channels, principal tributaries and small watersheds within the leasehold. These data, along with the runoff plots, were used to calibrate the EASI model soil erodibility and infiltration input variables. **Figures 2.1** and **2.2** show sediment transport and sediment concentration versus discharge for measured unmined (background), measured reclaimed, WA J16's modeled unmined (premine) and modeled reclaimed (postmine) data. Although there is significant scatter shown in the data (as is expected with any sediment transport conditions), there are several conclusions that can be drawn from this data.

The open symbols in both figures depict measured data and whether the data were collected from reclaimed areas (the small watershed study) or from unmined or background surface water monitoring stations. The range of flows is generally greater for the background data but there is significant overlap between the two data sets between 0.1 and 100 cfs. This is because the reclaimed data are from small watersheds and the unmined data are from channels draining larger basins. These data show the same trend for sediment transport and sediment concentration over the entire range of flows and very close agreement in the area of discharge overlap. This, in itself, is strong evidence that (1) the sediment yields are channel transport capacity limited, (2) overlap of model predictions for both pre- and postmine conditions with measured data strongly indicate that EASI model predictions are representative and reasonable, and (3) sediment yields from reclaimed areas will not be additive to yields on the receiving streams.

The closed symbols depict data from WA J16's pre- and postmine EASI model runs. They represent data generated by EASI for both subwatersheds and channels for peak discharges resulting from 2-, 5-, 10-, 25-, 50-, and 100-year storms. Using the peak flows from extreme events results in discharges that generally exceed 10 cfs. The trend of the model-derived data is similar and the ranges of concentration and sediment transport are similar to the measured data and between pre- and postmine conditions.

The sediment discharge plot (Figure 2.1) shows a stronger trend because it is plotting discharge (sediment) against discharge (flow). This is expected because the sediment discharge does depend on flow discharge. The concentration plot (Figure 2.2) shows the two separate variables and, therefore, a less significant trend. PWCC believes that data measurement may have some influence on the scatter (outliers were removed), but the process variability is probably the major influence. The majority of the data, however, fall in a group centered on 100 cfs and 100,000 mg/l, both in the observed data and in the model results. These plots support the use of the EASI model, the results of the modeling, the conclusion that sediment yields from reclaimed areas are not additive to receiving stream sediment loads, and that sediment impacts to the prevailing hydrologic balance have been minimized.

From Figures 2.1 and 2.2 it is apparent that sediment loads and concentrations are dependent on the channel sediment transport capacity for both pre- and postmine conditions. Channel sources of sediment in this arid environment are virtually unlimited. Therefore, channel transport capacity and channel derived sediment limits and governs sediment yields from the small tributaries, large channels and the WA as a whole. The similarity of sediment discharge (or concentration) between pre- and postmine conditions appears to be inconsistent with the lower rates of sediment yield shown in Table 1.4.

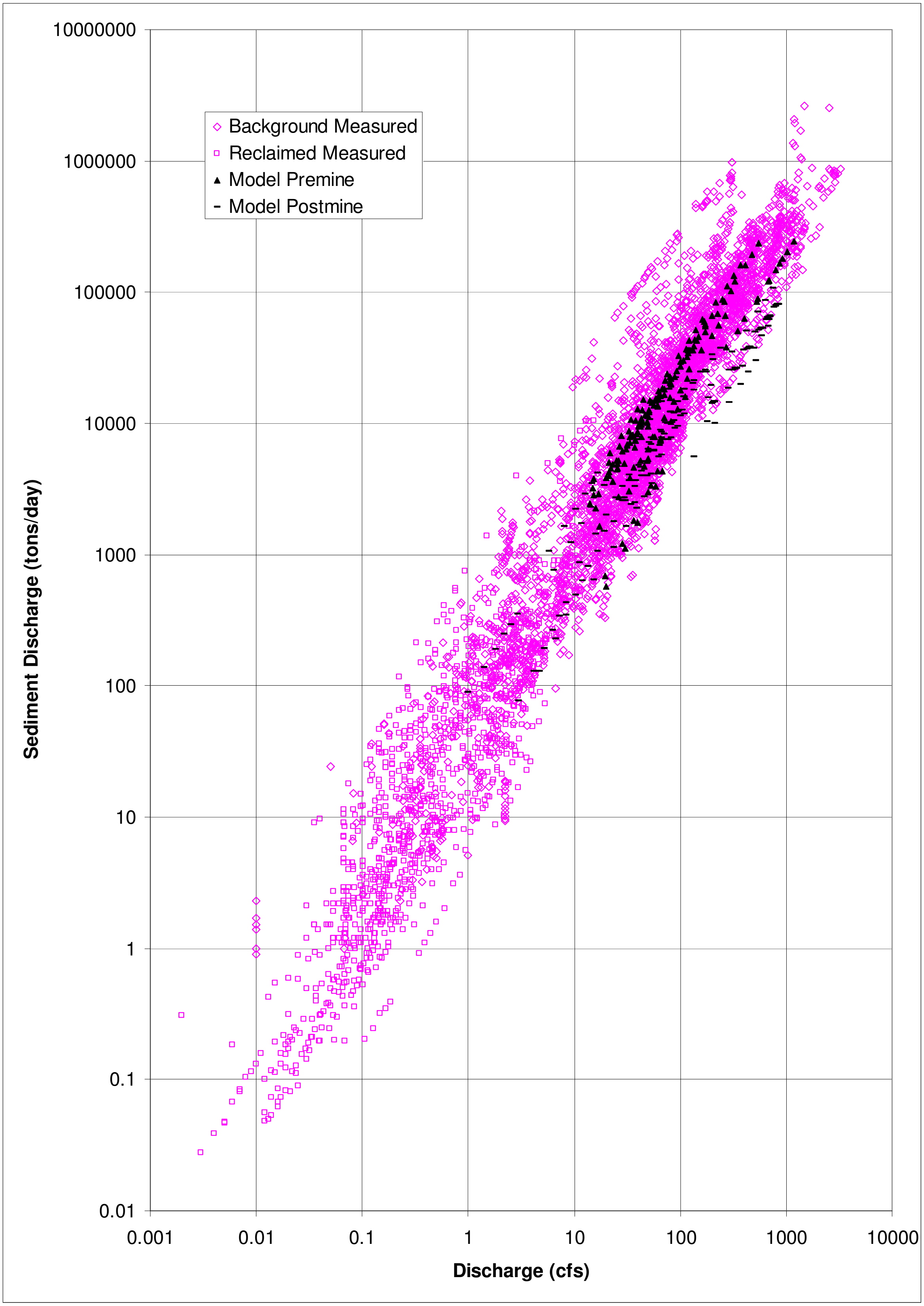

Figure 2.1. Observed and modeled sediment and water discharge.

Figure 2.2. Observed versus modeled sediment concentration and discharge.

However, the sediment yield shown in Table 1.4 is the average annual amount of sediment leaving the J16 WA whereas the sediment discharge shown in Figure 2.1 is the peak rate of sediment in transport occurring in any channel represented by the data, whether the channel is located upstream or downstream of a pond. Therefore, it should be concluded that with or without a pond left in the postmine landscape that traps sediment or stores water, the mine reclamation is not contributing additional sediment to the receiving streams and sediment impacts to the prevailing hydrologic balance have been minimized.

Smith and Best (2000) analyzed the measured data (background and reclaimed) shown in Figure 2.1 to develop an approach that can be used to determine if channels in reclaimed areas have similar sediment transport characteristics as background channels. The method that they used was to develop Sen lines (Sen 1968) and confidence intervals around the data. The slope of the Sen line is a non-parametric statistic computed as the median slope of all possible slopes determined from pairing all the data points. The Sen line is drawn through the median coordinate of the data. Smith and Best first showed that the large channel flume data (background) and the small watershed background data could be combined. They concluded that since the data from one data set fall within the Sen line bounds of the other data set then the two data sets are merely extensions of each other and could be combined. Also, because the main channel and background small watershed site data could be combined, it indicated there is an unlimited supply of sediment and the channels are conveying sediment at (or near) capacity. The Sen line and bounds are shown with the background measured data in **Figure 2.3**.

They then plotted the reclaimed measured data (**Figure 2.4**) with the Sen line and bounds from the background data to show that the reclaimed data have the same characteristics even though the flow range of the measurements is lower. The data indicate that channel flows in this environment achieve the sediment transport capacity of the channel, whether in reclaimed or background conditions.

Using the same approach with the modeled data generated for the J16 WA, **Figures 2.5 and 2.6** show the pre- and postmine computed sediment transport rates with the Sen lines and bounds. One difference between the plots is that the measured data occur throughout the flow hydrograph whereas the modeled data are tabulated at the peak of the simulation flow hydrograph. The premine data plot (Figure 2.5) shows the data grouped around the Sen line and well within the bounds. The postmine data (Figure 2.6) plot most densely below the Sen line and are more scattered. On these graphs data plotting below the lines indicate that there is less sediment in transport for a given discharge. The lower sediment transport rates in the reclaimed data is probably the result of low gradient channels while low gradient channels in the premine condition are rare.

Several conclusions can be drawn from these data plots: (1) EASI model well replicates erosion and sediment transport processes at the mine site for background and reclaimed conditions, (2) all data show similar trends and are within the same bounds, (3) data trends indicate that channels are transporting sediment at or near capacity, and (4) amounts of sediment leaving the WA for postmine conditions are similar to premine conditions and within the range expected for the background conditions. Therefore, the overall conclusion is that the postmine reclaimed condition in J16 WA is not contributing additional suspended solids to receiving streams, and related impacts to the hydrologic balance have been minimized.

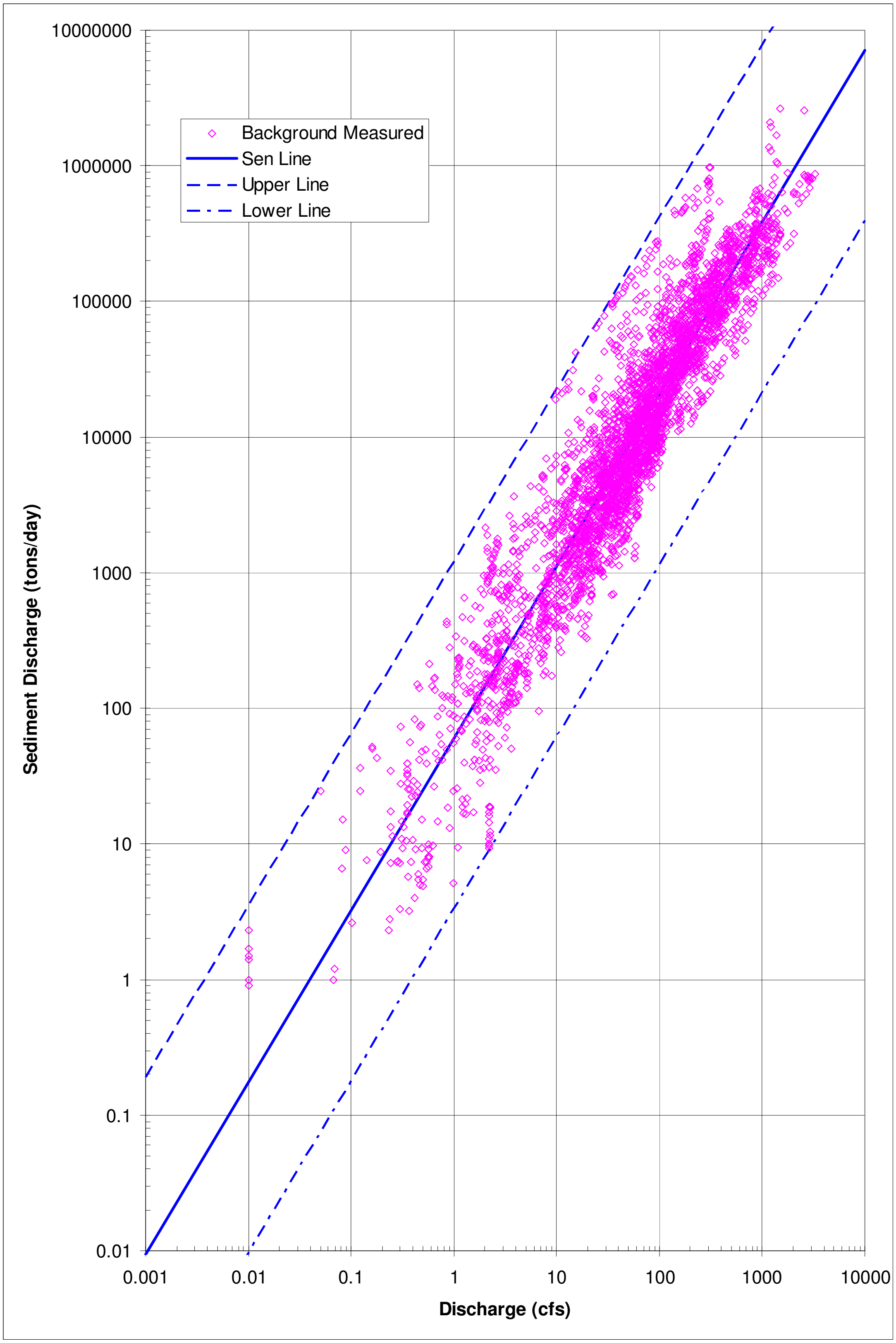

Figure 2.3. Background measured sediment and water discharge with Sen lines.

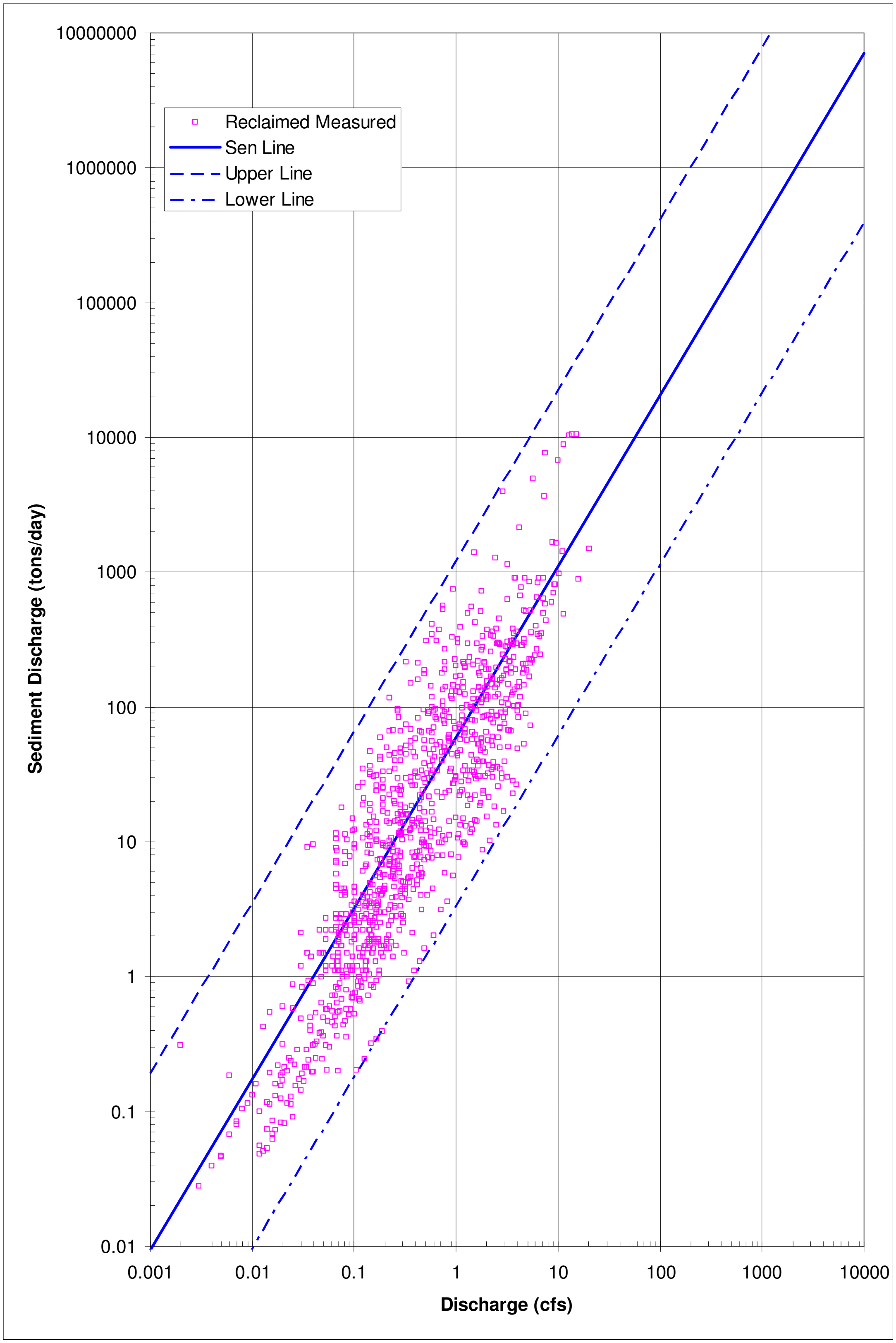

Figure 2.4. Reclaimed measured sediment and water discharge with Sen lines.

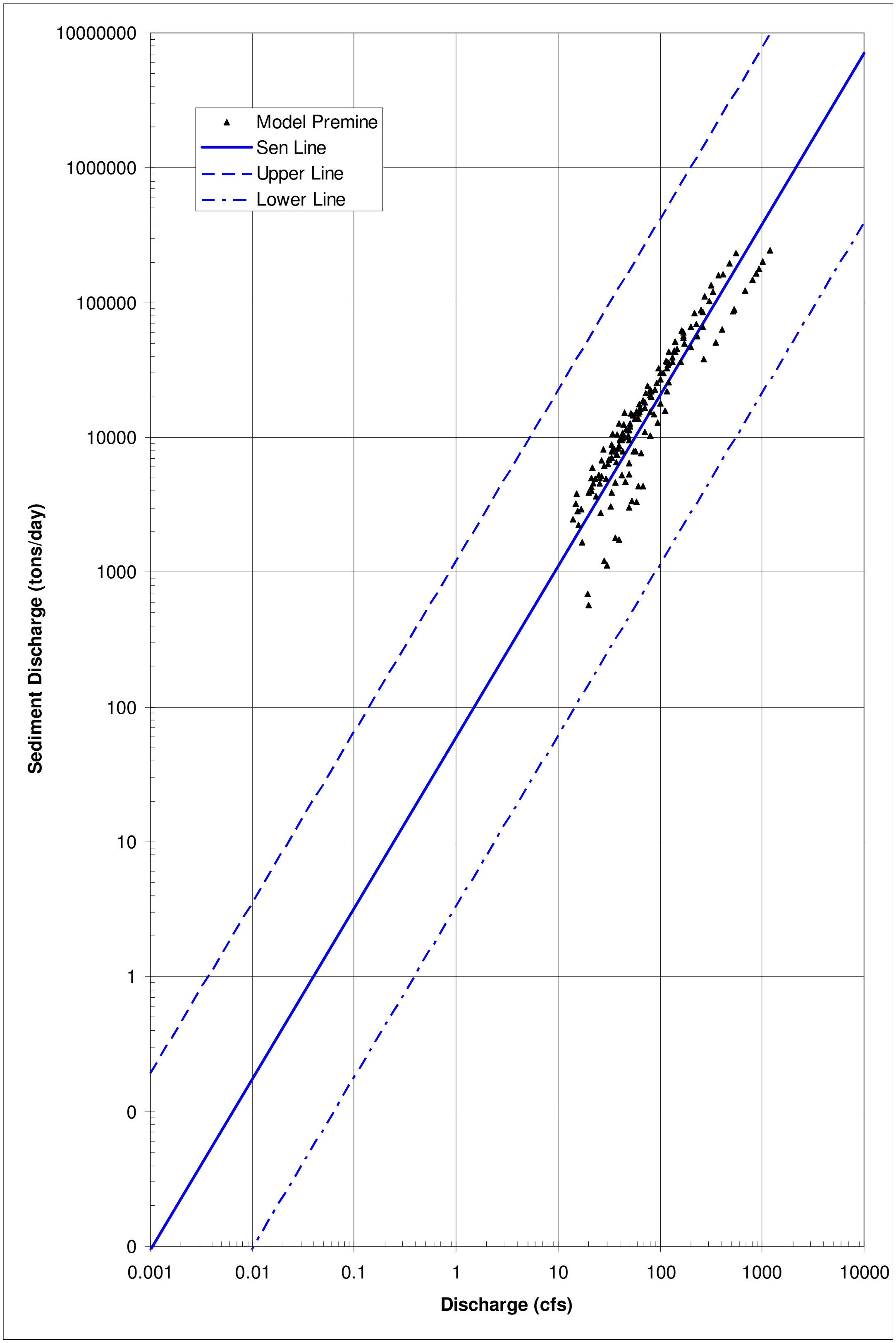

Figure 2.5. Modeled premine sediment and water discharge for the J16 WA with Sen lines.

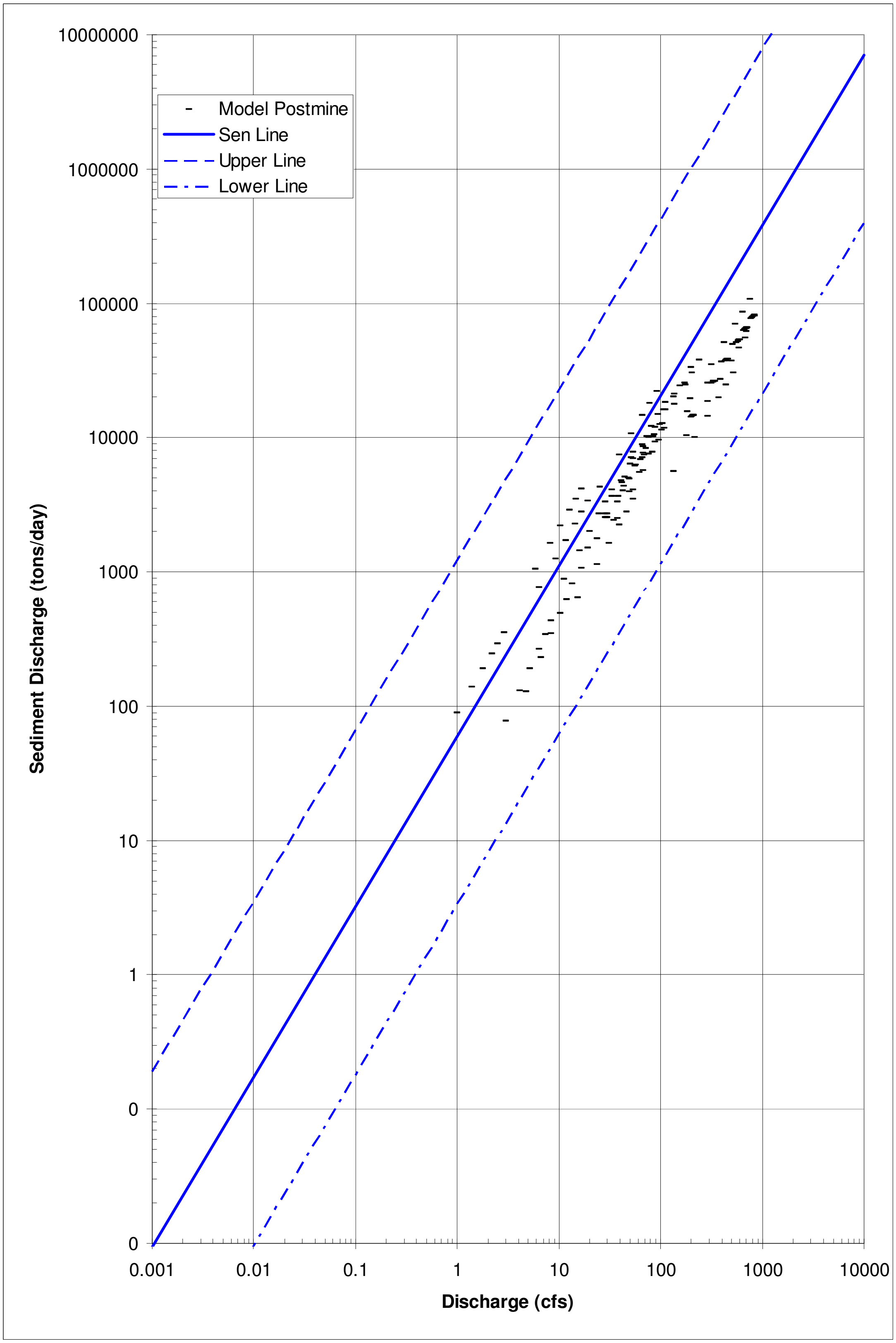

Figure 2.6. Modeled postmine sediment and water discharge for the J16 WA with Sen lines.

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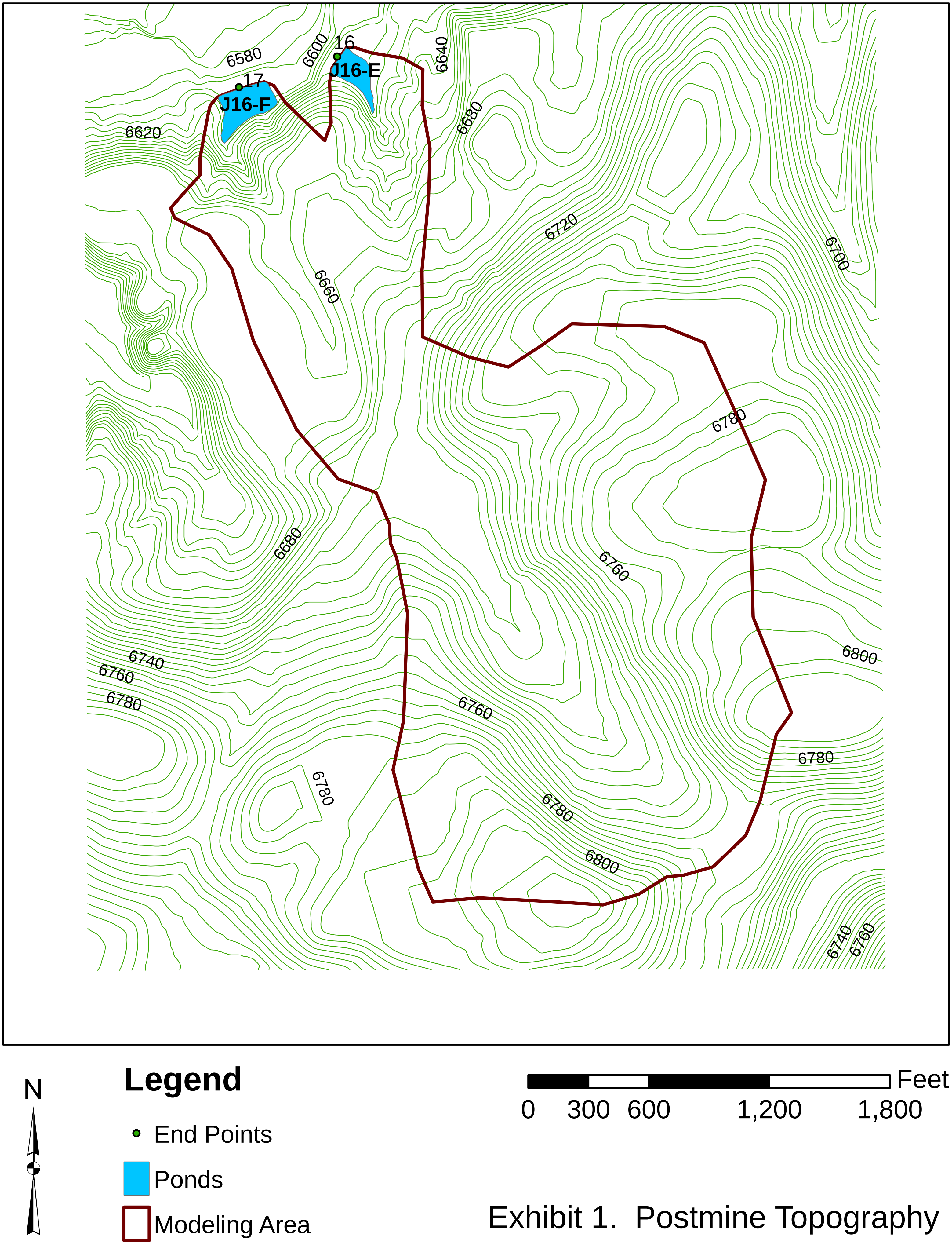

Exhibit 1. Postmine Topography

EXHIBIT 2
Premine Topography

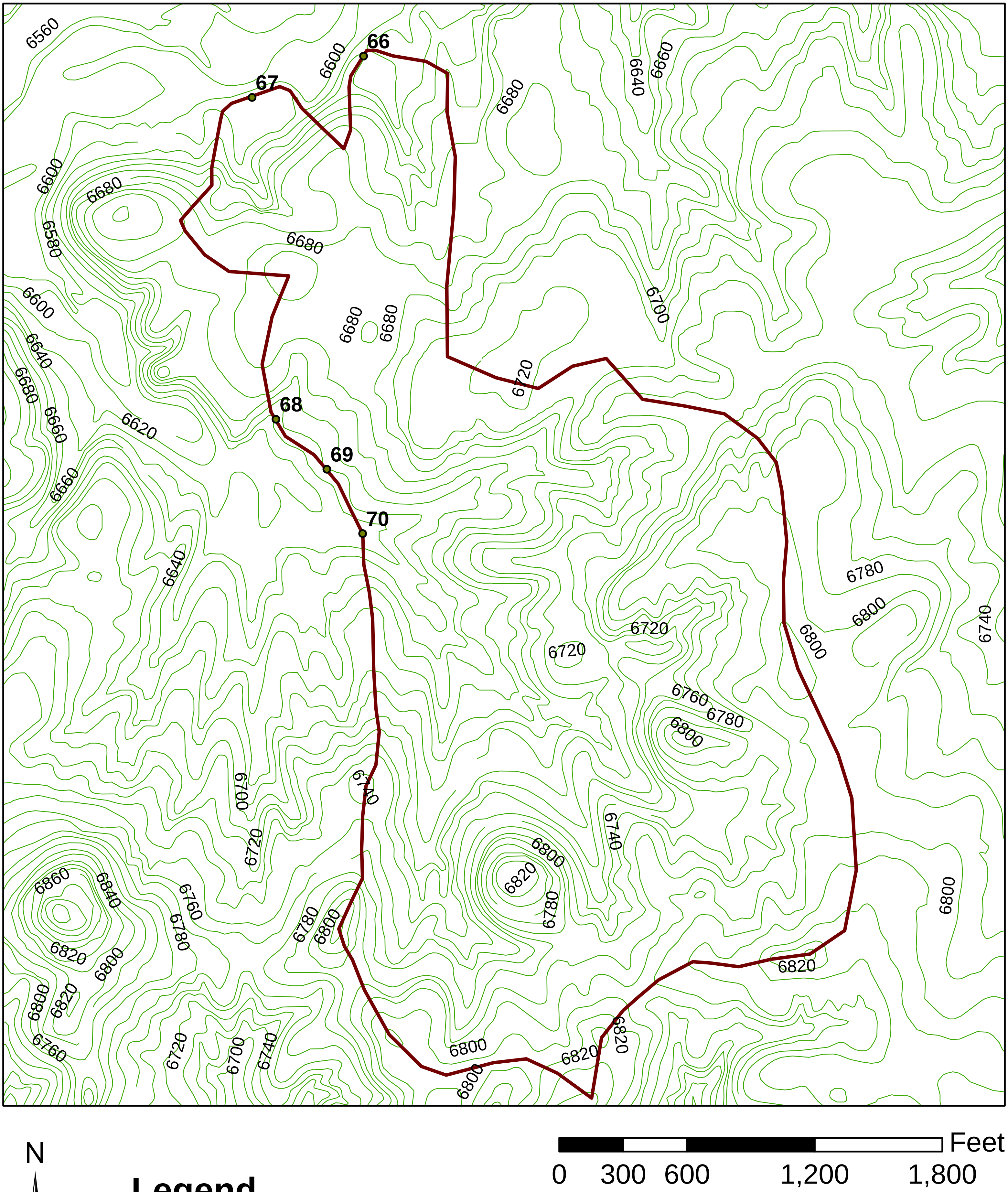

Exhibit 2. Premine Topography

Attachment 3-5c

Surface Water Modeling of the Reclaimed N14 Coal Resource
Area at Kayenta Mine

SURFACE WATER MODELING OF THE RECLAIMED N14 COAL RESOURCE AREA AT KAYENTA MINE

Prepared for

Peabody Western Coal Co.
Highway 160, Navajo Route 41
Kayenta, Arizona 86033

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1. INTRODUCTION

1.1 Background

Peabody Western Coal Company (PWCC) operates the Black Mesa and Kayenta surface coal mines, located approximately 25 miles southwest of Kayenta, Arizona. The mines are located on portions of the Hopi and Navajo Indian Tribal Lands. Mining operations occur on a physiographic feature known as the Black Mesa, which rises significantly higher in elevation than the surrounding areas. The mesa ranges in elevation from 6000 to 8000 feet while the surrounding areas range from 5000 to 5500 feet. The area is drained to the southwest via Moenkopi and Dinnebito washes to the Little Colorado River. The areas of present and future mining activity are located in the northeastern portion of the mesa at an elevation of 6200 to 7300 feet.

PWCC conducted a surface water monitoring program, also referred to as the Small Water Study (SWS) in three reclaimed coal resource areas denoted as J1/N6, N2, and J27 and in one undisturbed watershed denoted as J3. The SWS monitoring network consisted of 24 runoff plots, 7 flumes and 6 recording rain gages. The reclaimed coal resource areas in which monitoring was conducted resulted from sequential mining-related activities that began with vegetation removal and salvage of native topsoil. Following the removal of overburden and subsequent coal extraction, the spoiled overburden materials were regraded to form stable postmining topography. The regraded spoil was then covered with salvaged topsoil, disced, and revegetated with seed mixes selected to stabilize the landform and meet the proposed postmining land uses of livestock grazing and wildlife habitat.

Since 1980, PWCC has also monitored flow, suspended sediment, and water quality at 13 stream-gaging stations located on the eight main channels and principal tributaries transecting the PWCC leasehold. **Figure 1.1** shows the general location of the study area. In addition to hydrologic data, information has been collected describing vegetation parameters of cover, production and density, soil textural composition, and watershed topography.

1.2 Purpose

The purpose of this project was to evaluate the hydrologic and sediment yield response of reclaimed coal resource area N14 at the Kayenta Mine using a physical process-based watershed runoff and sediment yield model applicable to the conditions encountered at the mine site. Calibration and validation of the model were performed in a previous study (RCE 1993) using site-specific data collected under the SWS program. The response of the reclaimed coal resource areas was evaluated relative to undisturbed (premine) conditions in the corresponding undisturbed watersheds. The model serves as a tool for assessing the success of reclamation efforts to protect hydrologic balance (30 CFR 715.17 and 30 CFR 816.41).

The model selected for this project was EASI (Zevenbergen et al. 1990). This model is an enhanced version of the MULTSED model (Simons et al. 1978; Fullerton 1983), which has been demonstrated to be applicable for characterization of the effects of land disturbance and reclamation activities conducted at surface coal mine sites (WET 1990).

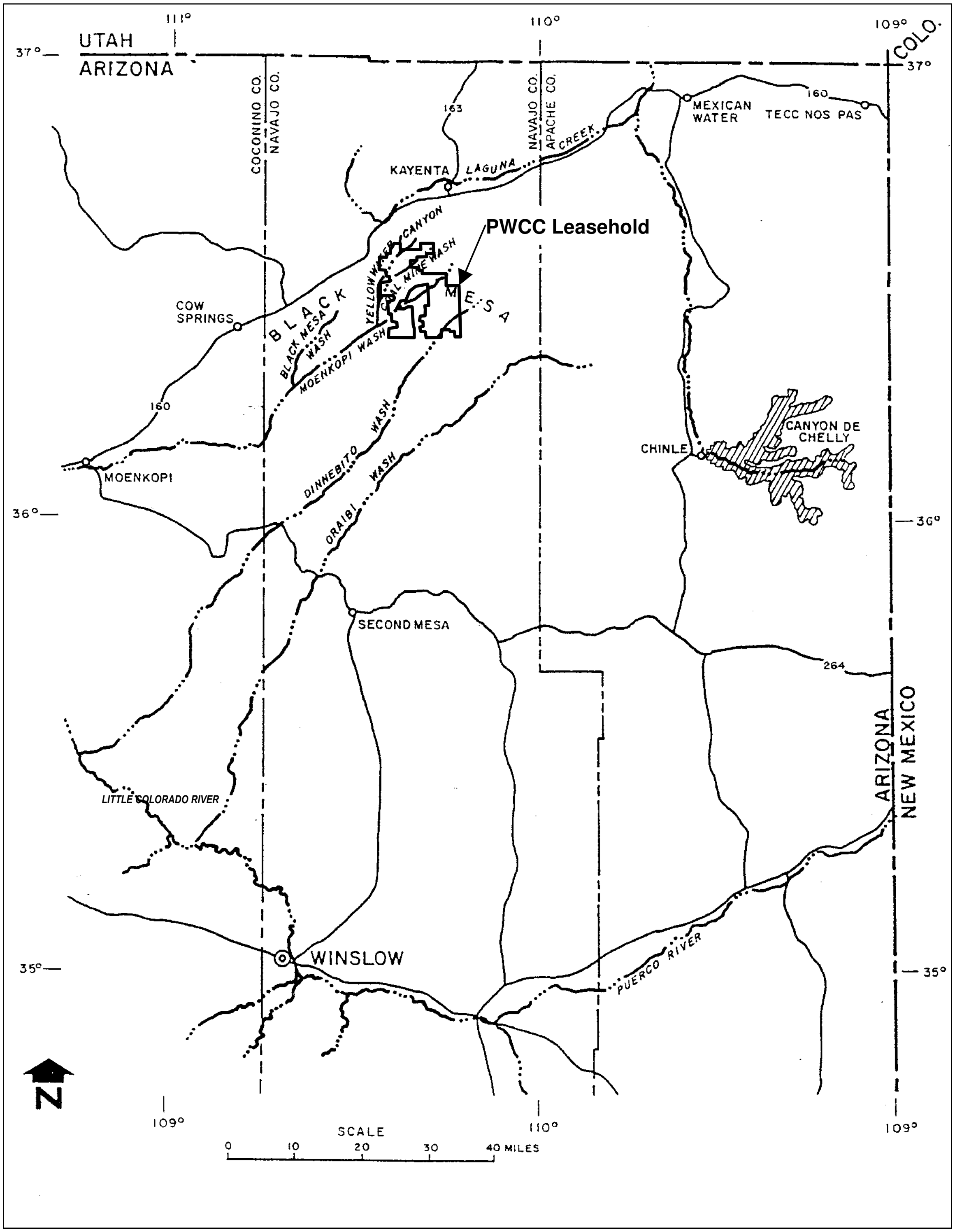

Figure 1.1. Location map.

1.3 Scope of Work

The objective defined by PWCC for this project is to use a previously calibrated and validated surface water model for the Black Mesa and Kayenta Mines to predict mean annual runoff and sediment yields from the reclaimed land parcel N14. This objective included computation of runoff and sediment yields under premine conditions for the same area. All soils and rainfall input to the model are to be taken from models calibrated in the previous study (RCE 1993). The input variables that were calibrated to the mine areas and used in this study include soil infiltration parameters, erodibility parameters, and the grain size distribution. Parameters that are specific to this study are vegetative canopy and ground cover percentages from data collected on site.

2. EASI MODEL CALIBRATION AND VALIDATION

2.1 Purpose

The purpose of the calibration/validation process was to develop a model that could be used to evaluate water and sediment runoff for a range of conditions that could not be directly evaluated under field conditions. Computer modeling of hydrologic processes is a commonly used method to evaluate watershed response and assess impacts of land-use change. When properly calibrated, the EASI model provides a means to make relative comparisons of response under pre- and postmine conditions.

The model calibration was conducted in a previous study (RCE 1993) using data obtained from instrumented watersheds and small hillslope plots collected under natural rainfall conditions. For a detailed discussion of data collection and model calibration, please refer to the previous study (RCE 1993).

2.2 Overview of EASI Model

The watershed runoff and sedimentation modeling program, Erosion And Sedimentation Impacts (EASI) was developed to aid in the analysis and development of various erosion and sedimentation control practices. It combines a sophisticated watershed modeling program with a user-friendly interface. EASI can be used to represent and analyze a complex watershed as a network of hillslopes, subwatersheds, channels, and ponds, each with uniquely identified soil, rainfall, land-use management, and topographic, or geometric characteristics. **Figure 2.1** shows a simple watershed as it would be represented within the EASI program. EASI calculates the runoff and sediment yield for each hillslope or nonpoint source area, determines the sediment transport capacity for the channels and trap efficiency for ponds, and deposits excess sediment or scours channels, depending on whether a sediment surplus or deficit exists. By analyzing erosion and sediment transport processes throughout the catchment, the model addresses nonpoint source areas and potential impacts throughout the channel network.

The EASI model represents an enhanced version of the program MULTSED (Simons et al. 1978), originally developed at Colorado State University under sponsorship of the U.S. Forest Service and the Environmental Protection Agency. Development of EASI entailed numerous modifications and enhancements to MULTSED. Among other features, EASI allows for modeling of complex hillslope geometry, incorporates level pool routing through ponds, provides flexibility in defining network connections, and includes computational algorithms to increase execution speed. EASI also provides a means for development of database files describing rainfall events, soil properties, and watershed management activities, as well as graphical and textual presentation of model results.

EASI was designed for simulation of single precipitation events with low base flow in relation to storm-generated runoff. Therefore, the model is ideally suited to simulate runoff and sediment yield in an arid to semiarid environment where ephemeral streams are common. The physiography of the Black Mesa Mining Complex embodies these conditions.

The following sections provide a brief overview of the major component processes simulated in EASI and their relative importance in the computation of runoff and sediment yield.

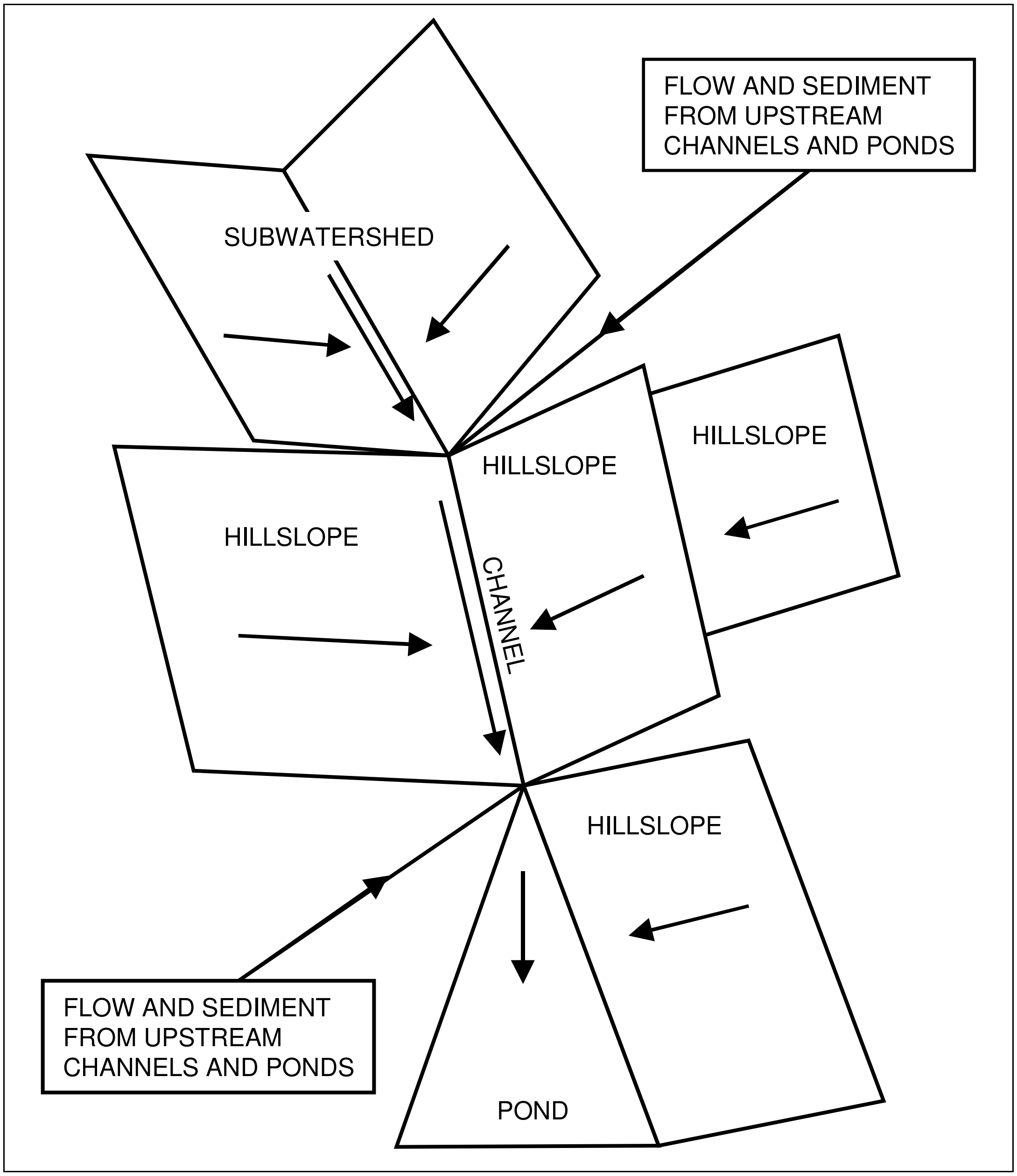

Figure 2.1. Example watershed representation within the EASI model.

2.2.1 Infiltration and Other Rainfall Abstractions

Short-duration, high-intensity summer thunderstorms dominate the runoff-producing events in the semiarid west. Such events produce runoff when the rainfall intensity exceeds the rate at which the soil can absorb water. This rate is dependant on soil properties, including porosity, antecedent soil moisture, capillary suction, and hydraulic conductivity. The Green and Ampt infiltration equation (Green and Ampt 1911) is used in the EASI model. This equation uses the soil characteristics to predict the soil infiltration rate throughout a storm, thereby determining the amount of surface runoff.

Rainfall which is trapped by surface vegetation (interception) or which accumulates in surface depressions (depression storage) is also unavailable for runoff. Canopy cover includes shrubs and trees. Ground cover includes grasses and other vegetation as well as rocks located on the ground surface. Depression storage includes natural depressions and man-made depressions (such as furrows and surface pitting). The aerial percentages of vegetative canopy and ground covers, the potential interception depth of the vegetation, and the average depression storage depth are required input to the EASI model.

2.2.2 Hillslope and Channel Flow Routing

Rainfall in excess of interception, infiltration, and depression storage generates runoff on hillslopes. Within the EASI model, the flow is routed down the hillslope using a finite difference solution to the kinematic wave flow representation. This modification to the original MULTSED model allows the analysis of complex hillslope geometries by cascading water and sediment from one hillslope to another. The hillslope is treated as a planar surface of constant slope and roughness. The roughness of the hillslope is represented by Manning's flow resistance parameter. Hillslopes supply water to channels, which in turn convey the water through the watershed. Channels are described by slope gradient, Manning's flow resistance parameter, and cross-section geometry. In the EASI model, channels can be either triangular, rectangular, or trapezoidal in cross section. The kinematic wave flow representation is also used for flow routing in channels. Channel infiltration can be significant in semiarid watersheds; this process is also simulated using the Green and Ampt infiltration equation.

2.2.3 Pond Flow Routing

Ponds store and retain runoff from upstream sources and also trap sediment. In the EASI model, MULTSED was modified to allow flow from hillslopes into ponds. If the storage and outflow characteristics of a pond are known, the impacts on watershed hydrologic and sediment responses can be predicted. The user provides a table of pond storage and outflow versus water surface elevation. If the outflow characteristics of the pond are not known, the user may input primary and emergency spillway characteristics (including inlet elevations, pipe sizes, spillway lengths, etc.) and the program will determine the outflow characteristics internally. EASI uses the level pool technique for routing flow through a pond (Chow 1951).

2.2.4 Soil Erosion

Soil erosion occurs when soil particles are detached by either raindrop impact or runoff forces. The susceptibility of soil to detachment is controlled by the cohesiveness, particle size, structure, and type of the soil. For noncohesive sandy soils, detachment of individual particles is not required prior to transport. In that case, the amount of erosion is limited by the capacity of flow to transport the soil. The EASI model requires detachment coefficients for raindrop impact and surface flow. The detachment coefficients may be determined through calibration or can be estimated using soil type and other soil characteristics as a guide. Based on the hillslope soil and channel sediment characteristics along with rainfall intensities and runoff rates, the model determines the total amount of sediment available for transport in each part of the watershed.

2.2.5 Sediment Transport

In the EASI model, sediment is transported on hillslopes and in channels by size fraction (ten size gradations are used ranging from primary clay to gravel sizes) using a sediment transport relationship composed of the Meyer-Peter, Muller bed-load equation (USBR 1960) and the Einstein suspended-load function (Einstein 1950). Because the amount of detached soil may be more or less than the amount of sediment which can be transported by the flow, the model can simulate supply-limited or capacity-limited sediment transport conditions. For example, a subwatershed containing hillslopes with relatively cohesive, low detachability soil with good vegetative cover may experience flows of high sediment transport capacity. The actual amount of sediment transported from this hillslope could be negligible because the soil characteristics and vegetation significantly reduce erosion. Conversely, a channel composed of fine sand could receive flow from the previously described hillslope. Because the sand does not require detachment prior to transport, the amount of sediment available for transport greatly exceeds that which the channel flow can transport. In this case, the channel flow will transport as much sediment as is physically possible based on the size gradation of the sand and energy of the flow. A watershed comprised of such hillslopes and channels could produce large quantities of sediment even though the hillslopes are not eroding.

Ponds are often used to limit the amount of sediment leaving mined land. The amount of sediment trapped by a pond is determined by the settling velocity of the sediment and the detention time of the runoff in the pond. The EASI program uses settling velocity (determined from the particle sizes) along with the pond storage and outflow characteristics to determine the trap efficiency of the pond. Because ponds are generally very efficient at trapping sediment, channel scour can occur downstream of a pond, depending on the outflow characteristics of the pond and the sediment characteristics of the downstream channels. In such a case, the pond may not significantly reduce the total amount of sediment produced by a watershed, but instead may change the sediment source from upstream of the pond to the channel downstream of the pond.

Table 2.1 shows the major input variables or parameters that must be estimated or computed for use in the EASI model.

Table 2.1. Major Input Data and Parameters for the EASI Model (after Simons et al. 1978).

Item	Typical Range
Geometry and Channel Data	
Watershed area	
Length of overland slopes	
Width of overland slopes	
Gradient of overland slopes	
Lengths of channel sections	
Gradient of channel sections	
Geometry of Channel Sections Pond Geometric and Outflow Characteristics	
Soil Data	
Particle size distribution	
Initial water content (saturation) of soil	0 - 100%
Final water content (saturation) of soil	0 - 100%
Saturated hydraulic conductivity	0.01 to 1.0 inches/hour
Capillary suction head	0.1 - 40 inches
Porosity	40 - 55%
Soil temperature	45 - 90 degrees F
Vegetation Data	
Density of ground cover	
Density of canopy cover	
Storage of ground and canopy covers	
Hydrologic Data	
Overland flow detachment coefficient	0.0 - 1.0
Channel flow detachment coefficient	0.0 - 1.0
Rainfall splash detachment coefficient	0.0001 - 0.013
Manning's n value	0.02 - 0.10

3. RECLAIMED PARCEL MODELING

3.1 Background

The N14 Coal Resource Area (CRA) that is the focus of this project was reclaimed between 1998 and 2002. The fundamental purpose of this study was to quantify the expected behavior and hydrologic response of the reclaimed areas relative to the conditions that existed prior to the occurrence of mining activities.

Runoff and sediment yield response from the reclaimed lands should be managed to not adversely impact the prevailing hydrologic balance and to limit additional contributions of suspended sediment to streamflow or runoff outside the mine permit areas. The natural watersheds on the mesa contribute significant quantities of sediment to the channel system. It is expected that the postmine condition will also produce comparable amounts of sediment without adverse impact on the hydrologic balance.

This section describes the data and procedures used to evaluate CRA N14. This area was modeled to determine the average annual hydrologic response following reclamation. Infiltration, runoff, and erosion processes from both hillslopes and channels within the CRA were modeled using EASI. Results were determined for concentration points at the outlets of the reclaimed watersheds. The locations of these points are shown in **Exhibit 1**. Modeling was also conducted to determine hydrologic response under premine conditions based on the topography, soils, cover, and other conditions that typified the undisturbed watersheds draining to each concentration point. **Exhibit 2** shows the modeling endpoints for the premine N14 watersheds.

3.2 Data

3.2.1 Soils

Soils data used for the current study (CRA N14) were based on data developed from the calibration of models used in the previous study (CRAs N1/N2 and J27) (RCE 1993). The composition of postmine soil in the current study is depicted along with the composition of postmine soils from the previous study in **Figure 3.1**. This figure shows that the soil composition of N14 is very similar to soils evaluated during model calibration. Therefore, the soil properties developed in the previous study are valid for this modeling project. These properties include calibrated parameters, such as infiltration and erodibility coefficients, and measured soil size distributions. **Table 3.1** lists the premine and postmine soils data used during EASI modeling of CRA N14.

3.2.2 Vegetation

Vegetative cover data representative of both pre- and postmine conditions in CRA N14 were supplied by PWCC. For the premine condition, land was characterized as being covered by sagebrush or pinon juniper. The spatial distribution of vegetative cover for the N14 premine condition appears in **Figure 3.2**. Average cover properties for CRAs N1/N2 and J27 of the previous study and N14 of the current study appear in **Table 3.2**. For the postmine condition, the entire area was assigned the same cover type. **Table 3.3** lists the pre- and postmine vegetative cover data used in the EASI model runs generated for the N14 CRA. Note that if a unit contained significant portions of both sagebrush and pinon juniper cover types, it was classified as half pinon juniper and half sagebrush.

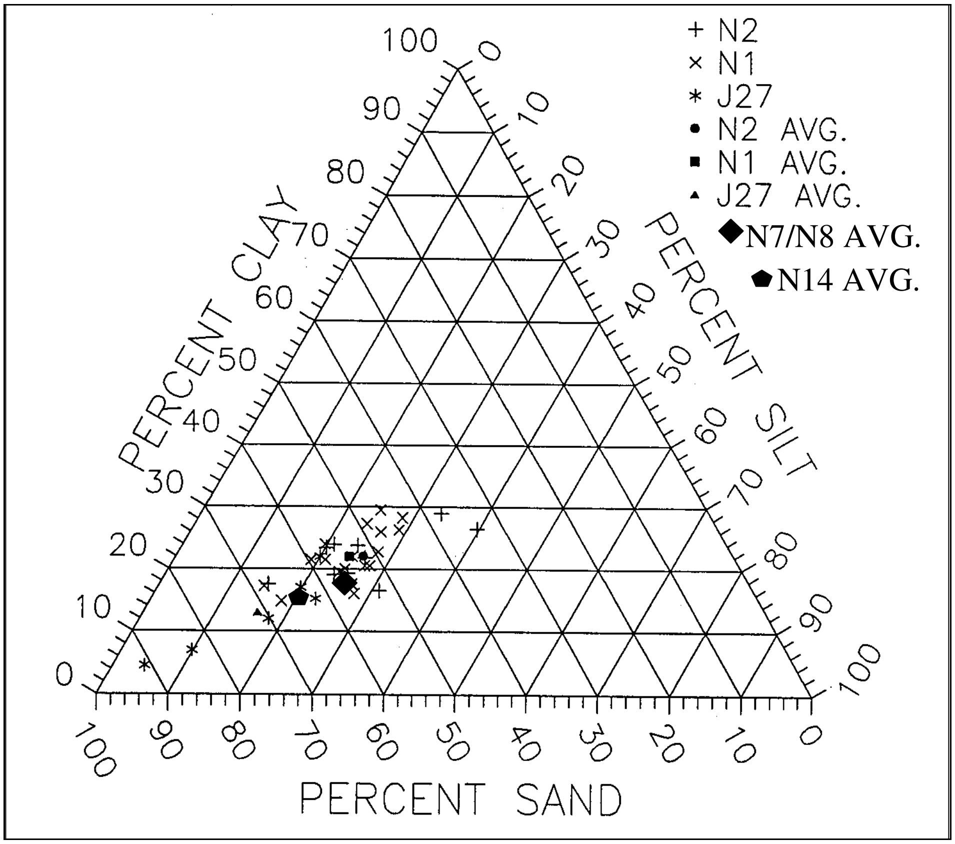

Figure 3.1. Reclaimed area soils trilinear graph.

Table 3.1. Soils Data.

Condition	Premine	Postmine	Rock Chutes
Rainfall detachment	0.005	0.005	0
Overland flow detachment	0.44	0.44	0
Channel flow detachment	0.5	0.5	0
Initial soil moisture, %	70	70	70
Final soil moisture, %	90	90	90
Soil porosity, %	45	45	46
Temperature, *F	70	70	70
Hydraulic conductivity, in/hr	0.23	0.29	0.3
Capillary suction, in	3.7	2.6	2.6
	Particle Size Distribution (all conditions)		
	Size, mm	% Finer	
	0.001	0	
	0.004	18.0	
	0.016	27.4	
	0.062	36.6	
	0.125	56.2	
	0.250	64.3	
	0.500	72.4	
	1.000	80.5	
	2.000	88.6	
	4.000	92.4	
	16.000	100	

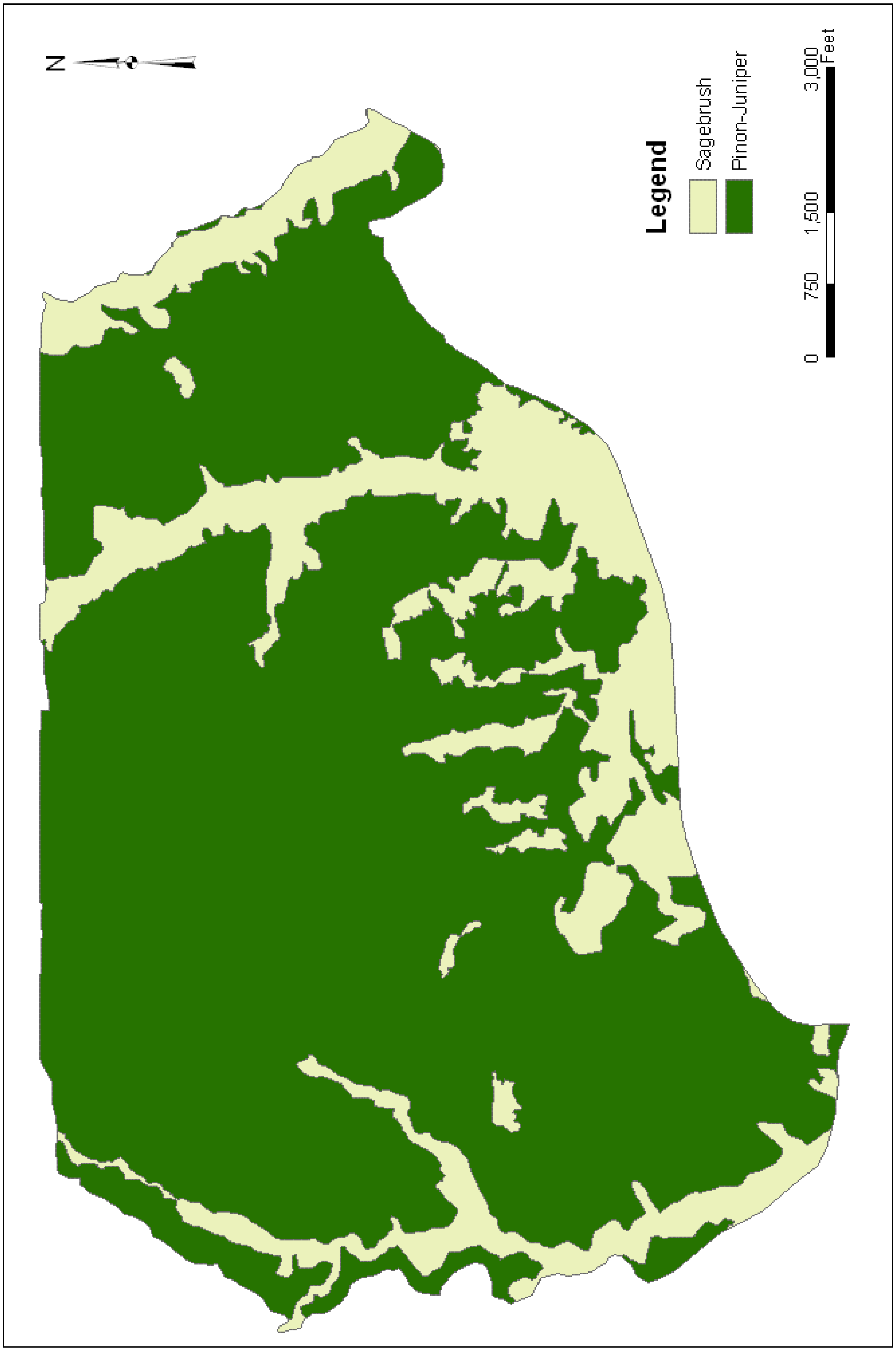

Figure 3.2. Spatial distribution of vegetative cover types for N14 premine condition.

Table 3.2. Cover Sampling Data.

Area	Condition	Cover Type	Nonstratified Vegetation Cover (%)	Vegetation Canopy Cover (%)	Vegetation Ground Cover (%)	Litter* (%)	Rock (%)	Total Ground Cover (%)
N1/N2	Postmine	Postmine	25.6	1.4	24.2	13.6	4.2	41.9
N14	Postmine	Postmine		0.9	16.1	25.8	4.6	46.5
N1/N2/J27	Premine	Pinon Juniper	32.7	31.1	3.0	44.0	19.7	66.7
N14	Premine	Pinon Juniper		13.9	4.5	24.4	17.5	46.4
N1/N2	Premine	Sagebrush	25.1	16.0	10.3	25.3	18.1	53.7
J27	Premine	Sagebrush	30.6	9.7	22.0	24.0	1.6	47.6
N14	Premine	Sagebrush		3.4	11.7	27	4.1	42.8

*Including standing dead litter

Table 3.3. Cover Data for N14.

Condition	Pinon Juniper	Sagebrush	Half Pinon Juniper-Half Sagebrush	Postmine
Canopy cover, %	13.9	3.4	8.65	0.9
Ground cover, %	46.4	42.8	44.6	46.5
Canopy storage, in	0.05	0.05	0.05	0.05
Ground storage, in	0.05	0.05	0.05	0.05
Depression storage, in	0.03	0.03	0.03	0.03
Impervious area, %	0	0	0	0
Manning n	0.07	0.07	0.07	0.05

3.2.3 Topography

Pre- and postmine topography was supplied by PWCC in the form of ArcGIS geodatabase. Basin delineations, hillslope delineations, subwatershed delineations, as well as areas, slopes, and lengths of all units of the study area were defined and calculated using ArcGIS software. **Figures 3.3 and 3.4** show the watershed delineation and descriptions assigned to the basins used in the EASI model for the post- and premine conditions, respectively. Channel dimensions input to EASI were based on the topography supplied and limited field observations.

3.3 Methodology

Runoff and sediment yield in the semiarid western United States is largely governed by the occurrence of high-intensity, short-duration rainstorms of limited areal extent (Renard and Simaton 1975). Research has indicated that relatively few events may produce the greatest erosion (e.g., Hjelmfelt et al. 1986 reported that only 3 to 4% of rainfall events accounted for 50% of long-term sediment yields). Although there is perhaps a relatively limited physical basis for definition of an "average annual" runoff or sediment yield in a semiarid environment due to the extreme variability in response and importance of single infrequent events, such a term does provide a useful basis for long-term comparison between reclaimed and undisturbed conditions.

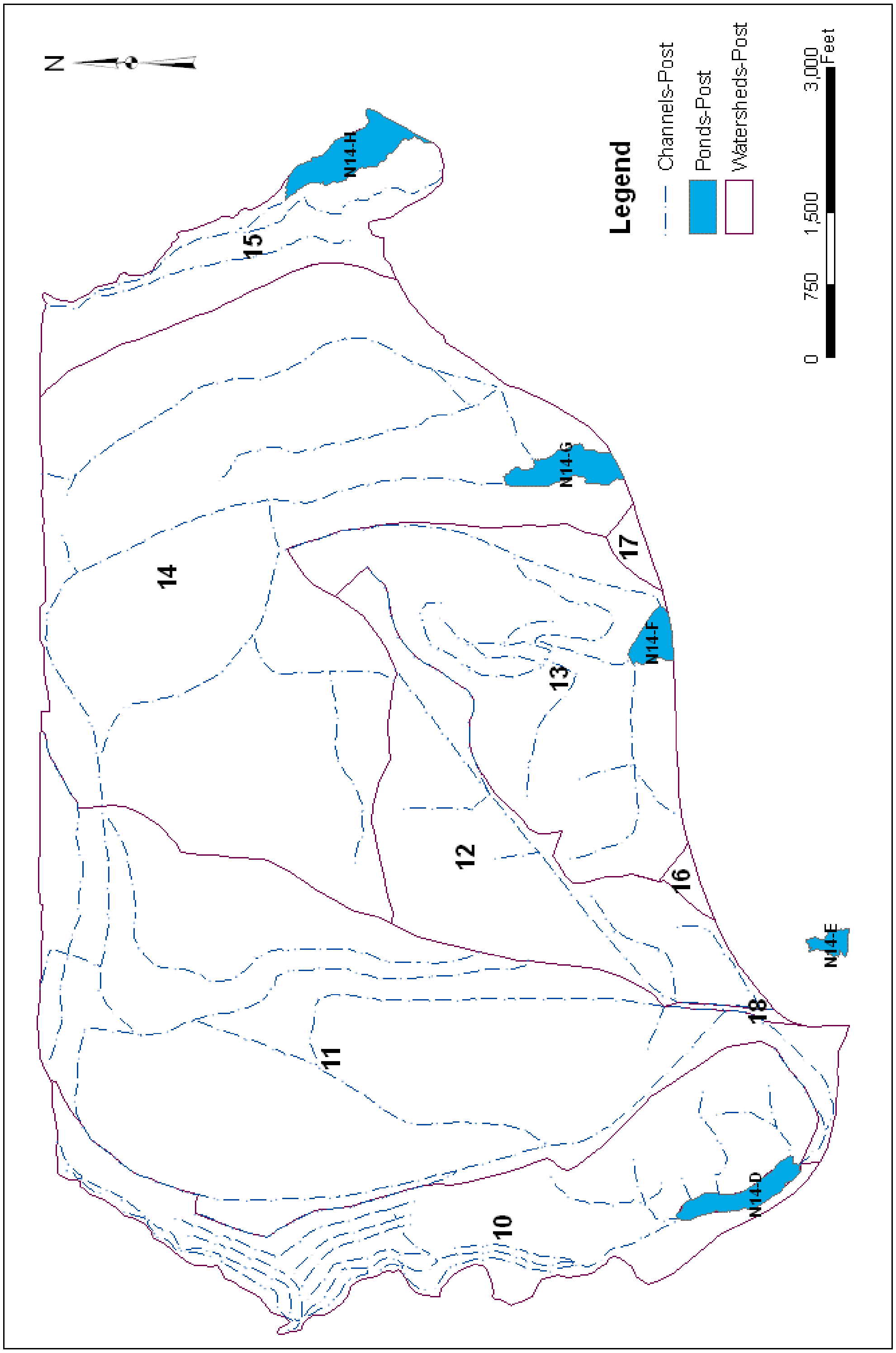

Figure 3.3. N14 postmine basins.

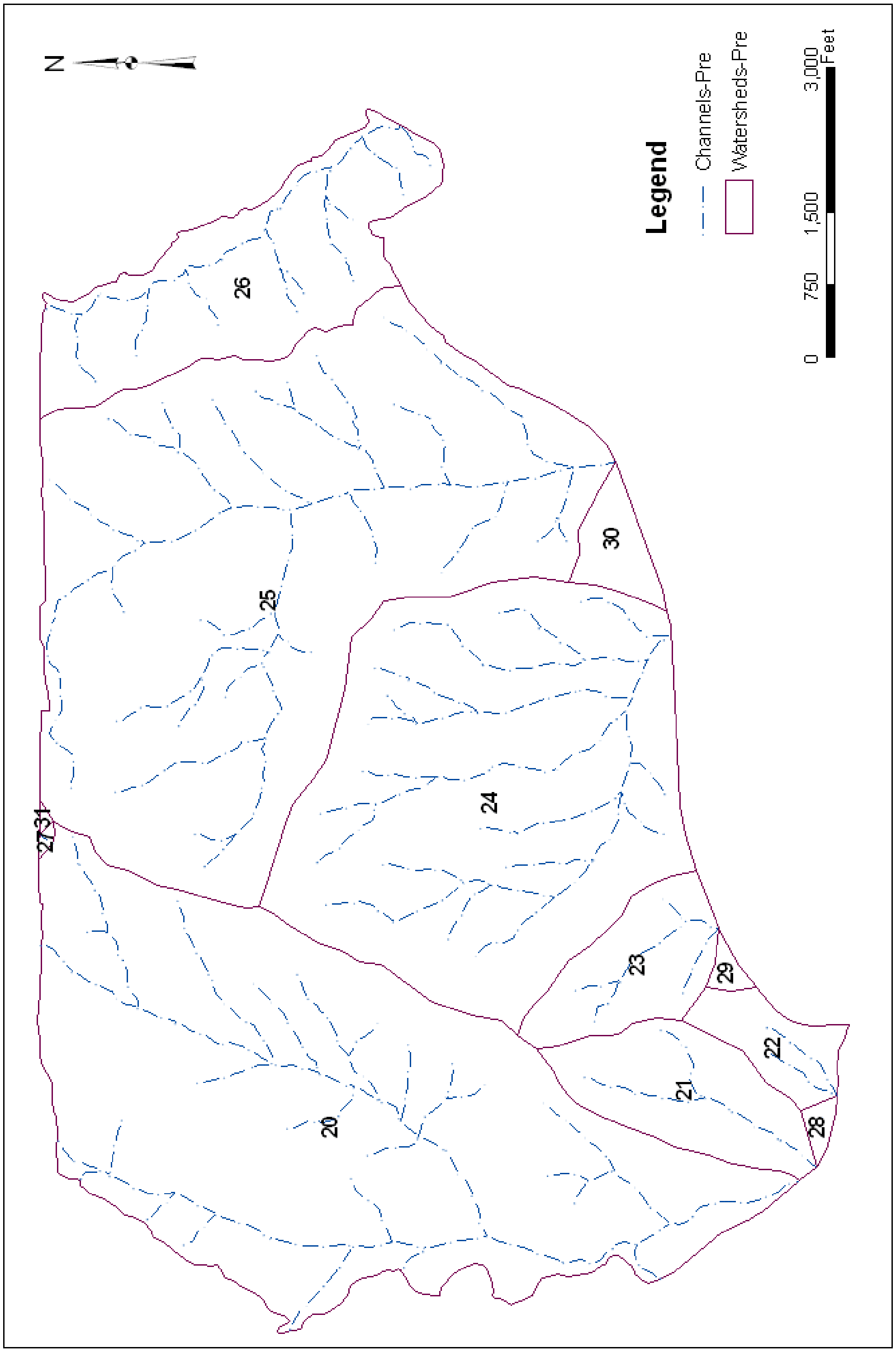

Figure 3.4. N14 premine basins.

To make comparisons between reclaimed lands and associated undisturbed lands at the Black Mesa Mining Complex on the basis of average annual sediment yield, a procedure was used that considers the importance of infrequent storm events in defining sediment yield in the semiarid west. First, however, the site-specific rainfall data available for the Black Mesa Mining Complex were used to evaluate the frequency and magnitude of the measured events relative to existing predictions for rainfall depth-duration (Miller et al. 1973). The analysis of the rainfall data was performed as part of a previous study of the N1/N2 and J27 CRAs (Resource Consultants and Engineers 1993).

Comparisons between runoff and sediment yield from undisturbed and reclaimed areas in CRA N14 were developed for specific modeling endpoints shown in Exhibits 1 and 2. Mining and reclamation activities did not exactly replicate the topography, drainage network, or drainage areas that existed prior to mining. Consequently, direct comparisons of total runoff and sediment yield cannot be made between undisturbed and reclaimed response at a given point in a watershed. Comparisons were made on the basis of unit rates of runoff (inches) and sediment yield (tons/acre) at the various modeling computation endpoints. Although the same disturbance boundary was used to model extents for both pre- and postmine conditions, the topographic differences that resulted after mining and reclamation occurred in the N14 CRA dictated that some small areas would be included or excluded from the modeling. The total area modeled for premine conditions is 1607.6 acres and for postmine conditions is 1580.6 acres. The difference in area results from the sediment ponds in postmine conditions. The area bounded by the disturbance limits identified by PWCC as shown in Exhibits 1 and 2 is 1607.6 acres.

3.3.1 Synthetic Rainfall

Synthetic storms of 2-, 5-, 10-, 25-, 50-, and 100-year return periods were used as input to the EASI model. Actual hyetographs were taken from the previous study (RCE 1993) and are based on both local data collection and the NOAA Atlas (Miller et al. 1973). **Table 3.4** lists the hyetographs used for each return period.

Table 3.4. Incremental Rainfall Intensities vs. Return Period.

Cumulative Time (min)	Incremental Intensity (in/hr)					
	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
5	0.29	0.38	0.45	0.54	0.61	0.69
10	0.76	0.99	1.19	1.43	1.61	1.82
15	2.01	2.61	3.14	3.75	4.23	4.79
20	4.16	5.40	6.51	7.76	8.76	9.92
25	1.20	1.56	1.88	2.24	2.53	2.87
30	0.35	0.46	0.55	0.66	0.74	0.84
40	0.20	0.27	0.32	0.38	0.43	0.49
50	0.12	0.15	0.18	0.22	0.24	0.28
60	0.11	0.14	0.17	0.21	0.23	0.26
80	0.11	0.14	0.17	0.20	0.23	0.26
100	0.07	0.09	0.11	0.13	0.15	0.17
120	0.05	0.06	0.07	0.08	0.09	0.11
150	0.05	0.06	0.07	0.08	0.09	0.11
180	0.05	0.06	0.07	0.08	0.09	0.10
360	0.05	0.05	0.05	0.06	0.06	0.07
1440	0.02	0.03	0.03	0.03	0.03	0.04
Total rainfall, in.	1.42	1.82	2.10	2.50	2.71	3.03

3.3.2 Computation of Average Runoff and Sediment Yield

The EASI model was used to evaluate runoff and sediment yield from a series of storm events having recurrence intervals of 2, 5, 10, 25, 50, and 100 years. To define average annual conditions, the average annual sediment yield $(Y_s)_m$ generated from storm events was computed using the following equation (Lagasse et al. 1985):

$$\begin{aligned}(Y_s)_m &= 0.01(Y_s)_{100} + 0.01\frac{(Y_s)_{100} + (Y_s)_{50}}{2} \\ &+ 0.02\frac{(Y_s)_{50} + (Y_s)_{25}}{2} + 0.06\frac{(Y_s)_{25} + (Y_s)_{10}}{2} \\ &+ 0.1\frac{(Y_s)_{10} + (Y_s)_{5}}{2} + 0.3\frac{(Y_s)_{5} + (Y_s)_{2}}{2} \\ &+ 0.5\frac{(Y_s)_{2} + 0}{2}\end{aligned} \tag{3.1}$$

In Equation 3.1, the subscripts denote return period of the storm in years. Equation 3.1 represents an integration of the sediment yield frequency curve based on the incremental probability of occurrence of relatively large storm events during any given year. Thus, Equation 3.1 considers the importance of high-intensity, short-duration rainfall on erosion processes in the study area. This procedure provides a consistent basis for comparison of sediment yield modeled for both undisturbed (premine) and reclaimed (postmine) conditions.

Average annual runoff was also computed using Equation 3.1, substituting storm event runoff volumes for sediment yields.

3.4 Results

Figures 3.3 and 3.4 show the post- and premine basin delineations. Since the individual subareas differ in number, acreage and outlet locations, a direct comparison is not possible on a subarea basis. Therefore, the best way to compare the results is on an average basis for the CRA. **Table 3.5** shows pre- and postmine drainage area, runoff, sediment yield, and erosion rates for the N14 CRA. Of course the pond greatly reduced sediment yield from the CRA. To consider the situation of pond removal for the postmine condition, the EASI model was run with sediment ponds replaced by channels. These channels are at the locations of the ponds and would discharge to a steep riprapped chute at the basin outlet. The channel is assumed to have a gentle slope of 1% and a length equal to the pond's length. Runoff is defined as the total volume of water leaving the CRA on an average annual basis and, therefore, does not include water stored in depression areas and ponds. For the premine condition, this is equal to the amount of water that drains off the hillslopes and subwatersheds because there are no ponds or significant depressions. For the postmine condition, this is equal to the amount of hillslope runoff less the amount stored in ponds. Similarly, the sediment yield is the amount of eroded material that leaves the CRA on an average annual basis computed using Equation 3.1. The sediment yield is the production from the hillslope areas and erosion from the channels. The amount of erosion tabulated in Table 3.5 is the sediment yield from the hillslopes and subwatersheds only and does not include channel erosion, channel deposition or sediment trapped in ponds. Sediment yield can be greater or less than erosion, depending on the amount of channel erosion and the capacity of the channel network to convey sediment off the leasehold.

Table 3.5. Average Runoff and Sediment Yield Results.					
CRA	Condition	Drainage Area (ac)	Runoff (in)	Sediment Yield (t/ac/yr)	Erosion (t/ac/yr)
N14	Premine	1,607.6	0.42	1.95	1.03
N14	Postmine	1,580.6	0.42	1.39	0.73

For the postmine condition, sediment yield is less than those in the premine condition. Sediment yield is approximately two-thirds of the premine amount, and runoff is the same as the premine amount. Hillslope and subwatershed erosion rates, which are significant from the perspective of postmine land use, are 30% lower for reclaimed (postmine) conditions. The reduction of sediment yield is due to the decrease of hillslope erosion and the channel erosion control measures for the postmine condition.

3.5 Discussion

Table 3.6 gives an overview of the geometric properties of the pre- and postmine disturbed areas. Premine hillslopes are generally longer than postmine hillslopes, postmine channels are not as steep as premine channels, and the drainage density of the postmine condition is greater than that of the premine condition. These properties agree with the postmine versus premine topography: the greater drainage density and shorter hillslopes of the postmine condition are due to the terracing of the land to allow less sediment erosion and transport. Generally, in a natural setting, a greater drainage density would be equated with higher sediment yields. However, the terraces are not "natural" channels as they are designed to segment long hillslopes into shorter lengths and the terrace channels are designed with low gradients to reduce erosion and sediment transport. A high drainage density in a natural setting would result in a short time of concentration and higher peak flows but a high drainage density due to terracing would increase time of concentration and decrease peak flows. Such differences in pre- and postmine topography make it difficult to generalize about sediment yield from pre- and postmine areas. This shows the value of modeling. One generalization that can be made, however, is that the significantly shorter hillslope lengths are the cause of lower erosion rates.

Table 3.6. Average Physical Properties of N14.		
	Premine	Postmine
Total Area (ac)	1607.6	1580.6
Total Channel Length (ft)	114,764	134,200
Mean Channel Slope	0.0684	0.0328
Drainage Density (mi/mi^2)	8.7	10.3
Mean Hillslope Length (ft)	304	274
Mean Hillslope Gradient	0.1324	0.1115

4. COMPARISONS WITH MEASURED SEDIMENT TRANSPORT

As discussed in Section 1, PWCC has monitored flow and sediment on the main channels, principal tributaries and small watersheds within the leasehold. These data, along with the runoff plots, were used to calibrate the EASI model soil erodibility and infiltration input variables. **Figures 4.1** and **4.2** show sediment transport and sediment concentration versus discharge for measured unmined (background), measured reclaimed, modeled unmined (premine) and modeled reclaimed (postmine) data. Although there is significant scatter shown in the data (as is expected with any sediment transport conditions), there are several conclusions that can be drawn from this data.

The open symbols in both figures depict measured data and whether the data were collected from reclaimed areas (the small watershed study) or from unmined or background surface water monitoring stations. The range of flows is generally greater for the background data but there is significant overlap between the two data sets between 0.1 and 100 cfs. This is because the reclaimed data are from small watersheds and the unmined data are from channels draining larger basins. These data show the same trend for sediment transport and sediment concentration over the entire range of flows and very close agreement in the area of discharge overlap. This, in itself, is strong evidence that (1) the sediment yields are channel transport capacity limited, (2) overlap of model predictions for both pre- and postmine conditions with measured data strongly indicate that EASI model predictions are representative and reasonable, and (3) sediment yields from reclaimed areas will not be additive to yields on the receiving streams.

The closed symbols depict data from the pre- and postmine EASI model runs. They represent data generated by EASI for both subwatersheds and channels for peak discharges resulting from 2-, 5-, 10-, 25-, 50-, and 100-year storms. Using the peak flows from extreme events results in discharges that generally exceed 10 cfs. The trend of the model-derived data is similar and the ranges of concentration and sediment transport are similar to the measured data and between pre- and postmine conditions.

The sediment discharge plot (Figure 4.1) shows a stronger trend because it is plotting discharge (sediment) against discharge (flow). This is expected because the sediment discharge does depend on flow discharge. The concentration plot (Figure 4.2) shows the two separate variables and, therefore, a less significant trend. PWCC believes that data measurement may have some influence on the scatter (outliers were removed), but the process variability is probably the major influence. The majority of the data, however, fall in a group centered on 100 cfs and 100,000 mg/l, both in the observed data and in the model results. These plots support the use of the EASI model, the results of the modeling, the conclusion that sediment yields from reclaimed areas are not additive to receiving stream sediment loads, and that sediment impacts to the prevailing hydrologic balance have been minimized.

From Figures 4.1 and 4.2 it is apparent that sediment loads and concentrations are dependent on the channel sediment transport capacity for both pre- and postmine conditions. Channel sources of sediment in this arid environment are virtually unlimited. Therefore, channel transport capacity and channel derived sediment limits and governs sediment yields from the small tributaries, large channels and the CRA as a whole. The similarity of sediment discharge (or concentration) between pre- and postmine conditions appears to be inconsistent with the lower rates of sediment yield shown in Table 3.5.

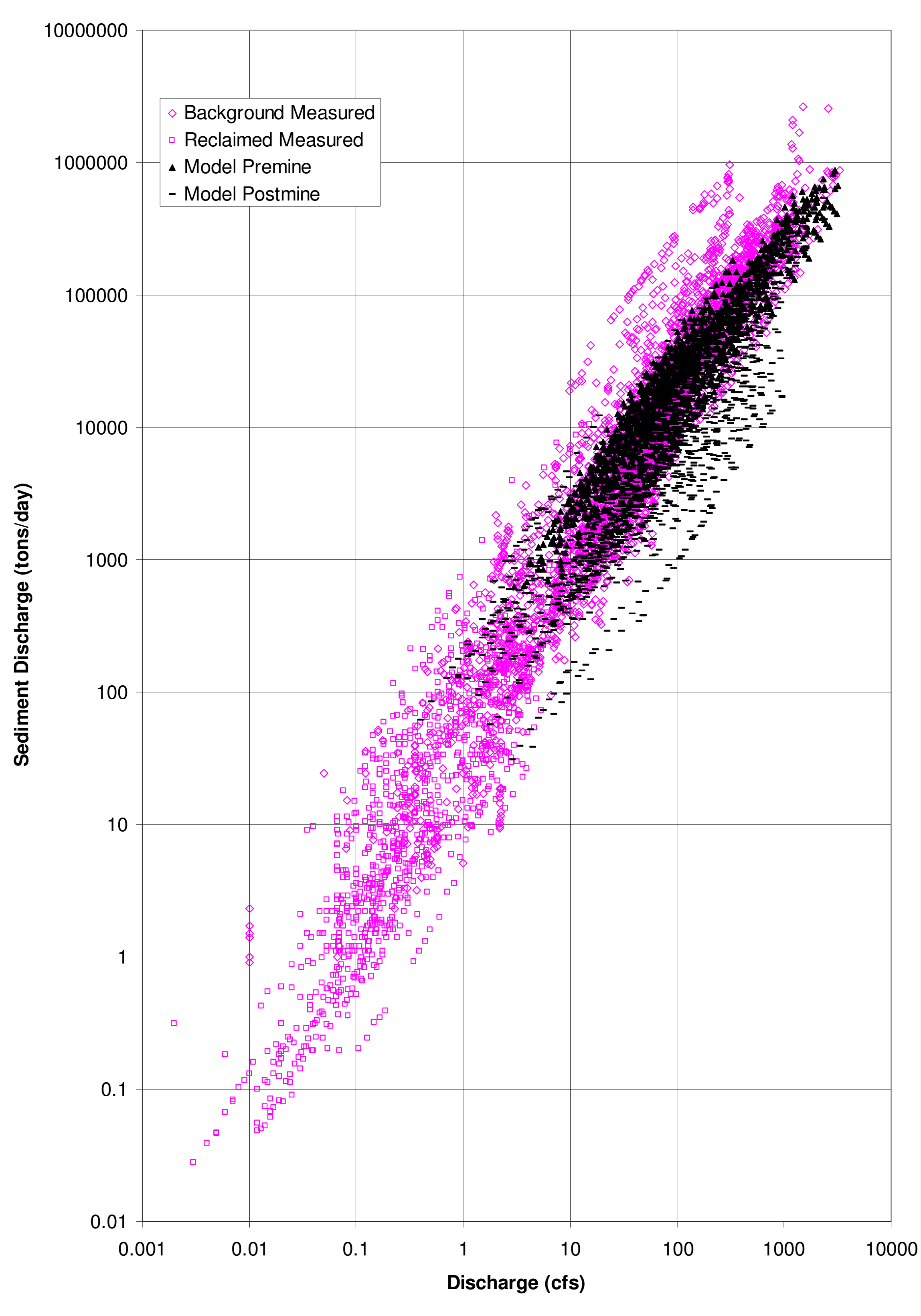

Figure 4.1. Observed and modeled sediment and water discharge.

Figure 4.2. Observed versus modeled sediment concentration and discharge.

However, the sediment yield shown in Table 3.5 is the amount of sediment leaving the CRA whereas the sediment discharge shown in Figure 4.1 is the peak rate of sediment in transport occurring in any channel on the CRA, whether the channel is located upstream or downstream of a pond. Therefore, it should be concluded that with or without the ponds trapping sediment or storing water, the mine reclamation is not contributing additional sediment to the receiving streams and sediment impacts to the prevailing hydrologic balance have been minimized.

Smith and Best (2000) analyzed the measured data (background and reclaimed) shown in Figure 4.1 to develop an approach that can be used to determine if channels in reclaimed areas have similar sediment transport characteristics as background channels. The method that they used was to develop Sen lines (Sen 1968) and confidence intervals around the data. The slope of the Sen line is a non-parametric statistic computed as the median slope of all possible slopes determined from pairing all the data points. The Sen line is drawn through the median coordinate of the data. Smith and Best first showed that the large channel flume data (background) and the small watershed background data could be combined. They concluded that since the data from one data set fall within the Sen line bounds of the other data set then the two data sets are merely extensions of each other and could be combined. Also, because the main channel and background small watershed site data could be combined, it indicated there is an unlimited supply of sediment and the channels are conveying sediment at (or near) capacity. The Sen line and bounds are shown with the background measured data in **Figure 4.3**.

They then plotted the reclaimed measured data (**Figure 4.4**) with the Sen line and bounds from the background data to show that the reclaimed data have the same characteristics even though the flow range of the measurements is lower. The data indicate that channel flows in this environment achieve the sediment transport capacity of the channel, whether in reclaimed or background conditions.

Using the same approach with the modeled data, **Figures 4.5 and 4.6** show the pre- and postmine computed sediment transport rates with the Sen lines and bounds. One difference between the plots is that the measured data occur throughout the flow hydrograph whereas the modeled data are tabulated at the peak of the simulation flow hydrograph. The premine data plot (Figure 4.5) shows the data tightly grouped around the Sen line and well within the bounds. The postmine data (Figure 4.6) plot most densely just below the Sen line and are more scattered. A few data points plot below the lower bound. On these graphs data plotting below the lines indicate that there is less sediment in transport for a given discharge. The lower sediment transport rates in the reclaimed data is probably the result of low gradient channels (in some cases terraces) while low gradient channels in the premine condition are rare.

Several conclusions can be drawn from these data plots: (1) EASI model well replicates erosion and sediment transport processes at the mine site for background and reclaimed conditions, (2) all data show similar trends and are within the same bounds, (3) data trends indicate that channels are transporting sediment at or near capacity, and (4) amounts of sediment leaving the CRA for postmine conditions are similar to premine conditions and within the range expected for the background conditions. Therefore, the overall conclusion is that the postmine reclaimed condition in N14 is not contributing additional suspended solids to receiving streams, and related impacts to the hydrologic balance have been minimized."

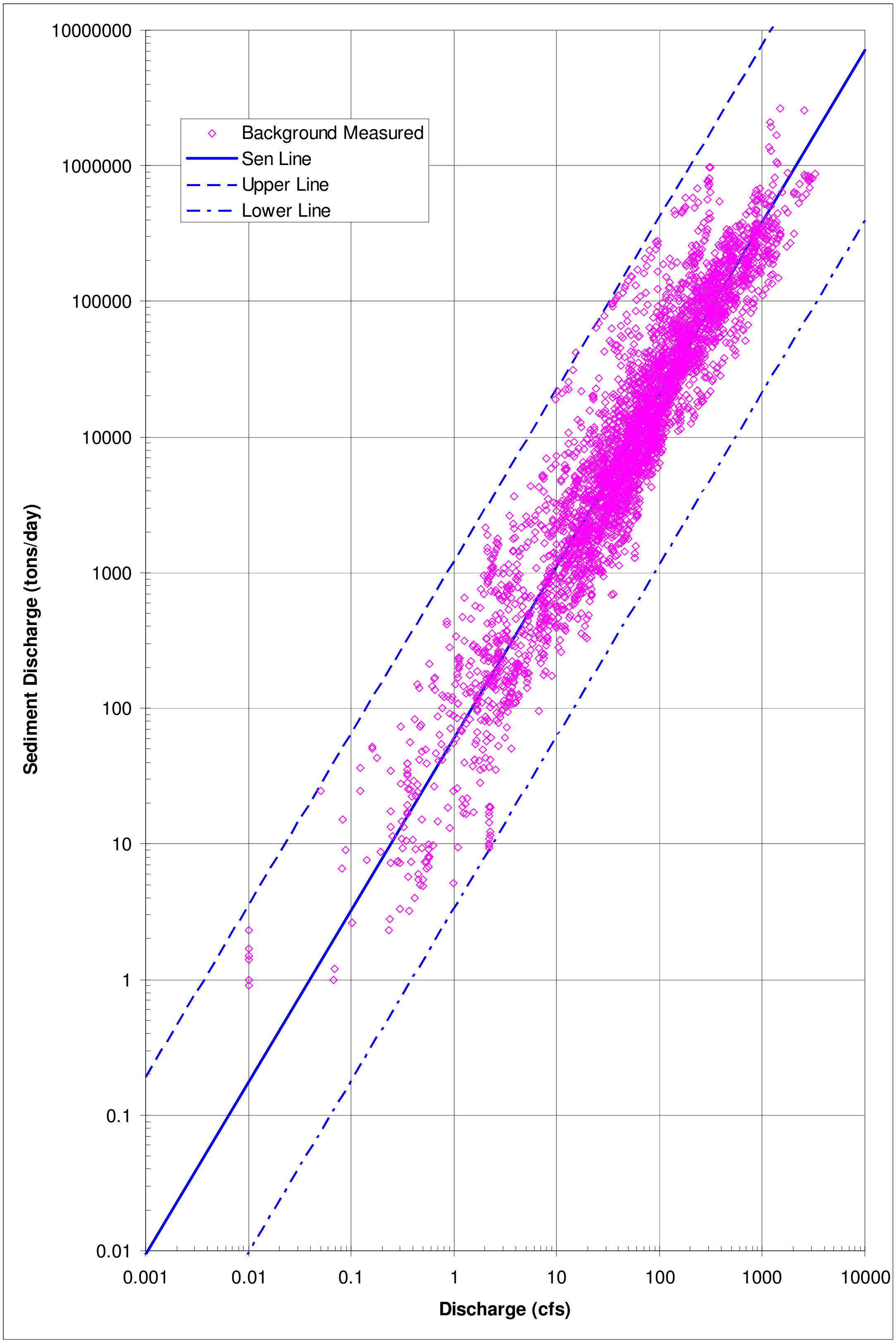

Figure 4.3. Background measured sediment and water discharge with Sen lines.

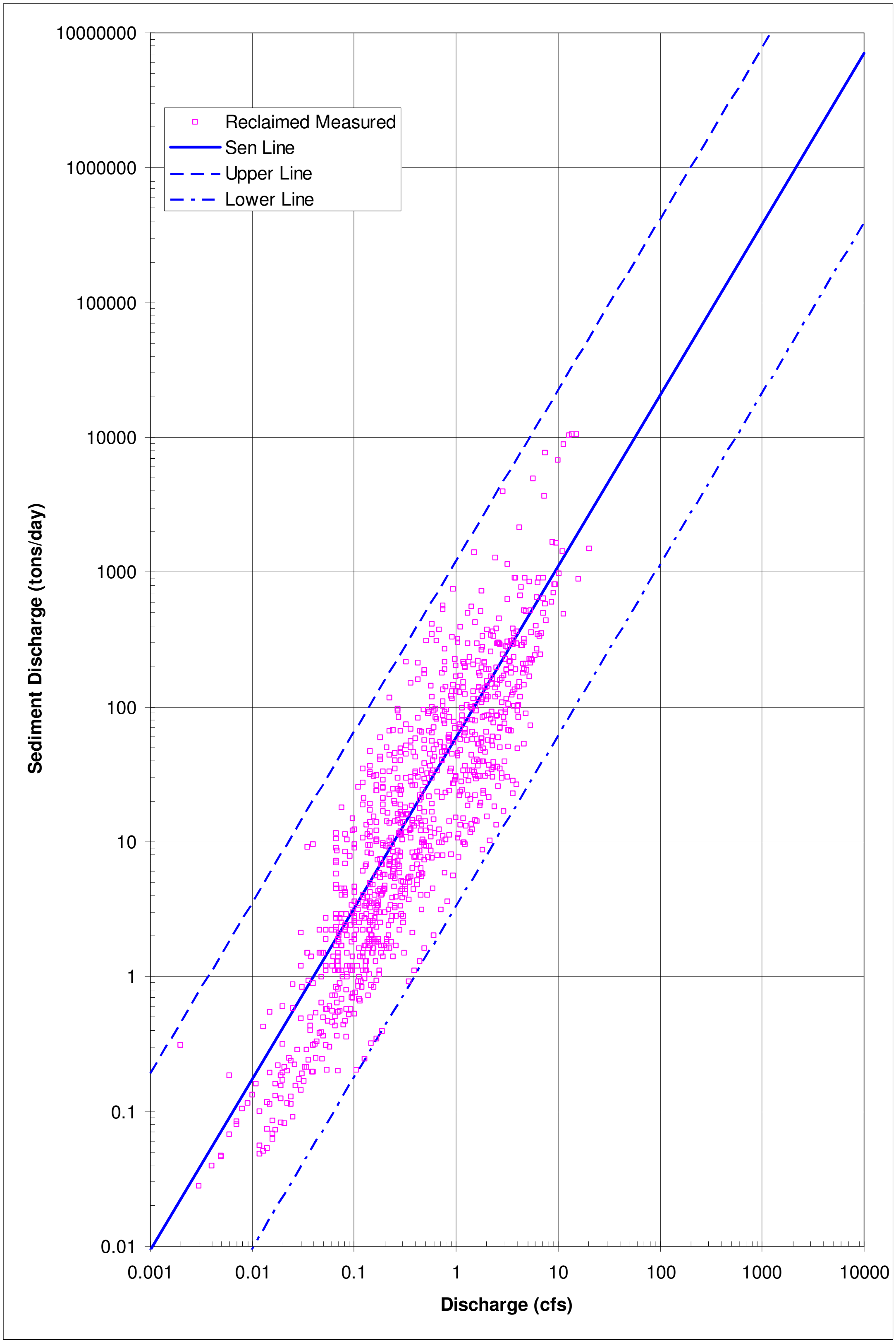

Figure 4.4. Reclaimed measured sediment and water discharge with Sen lines.

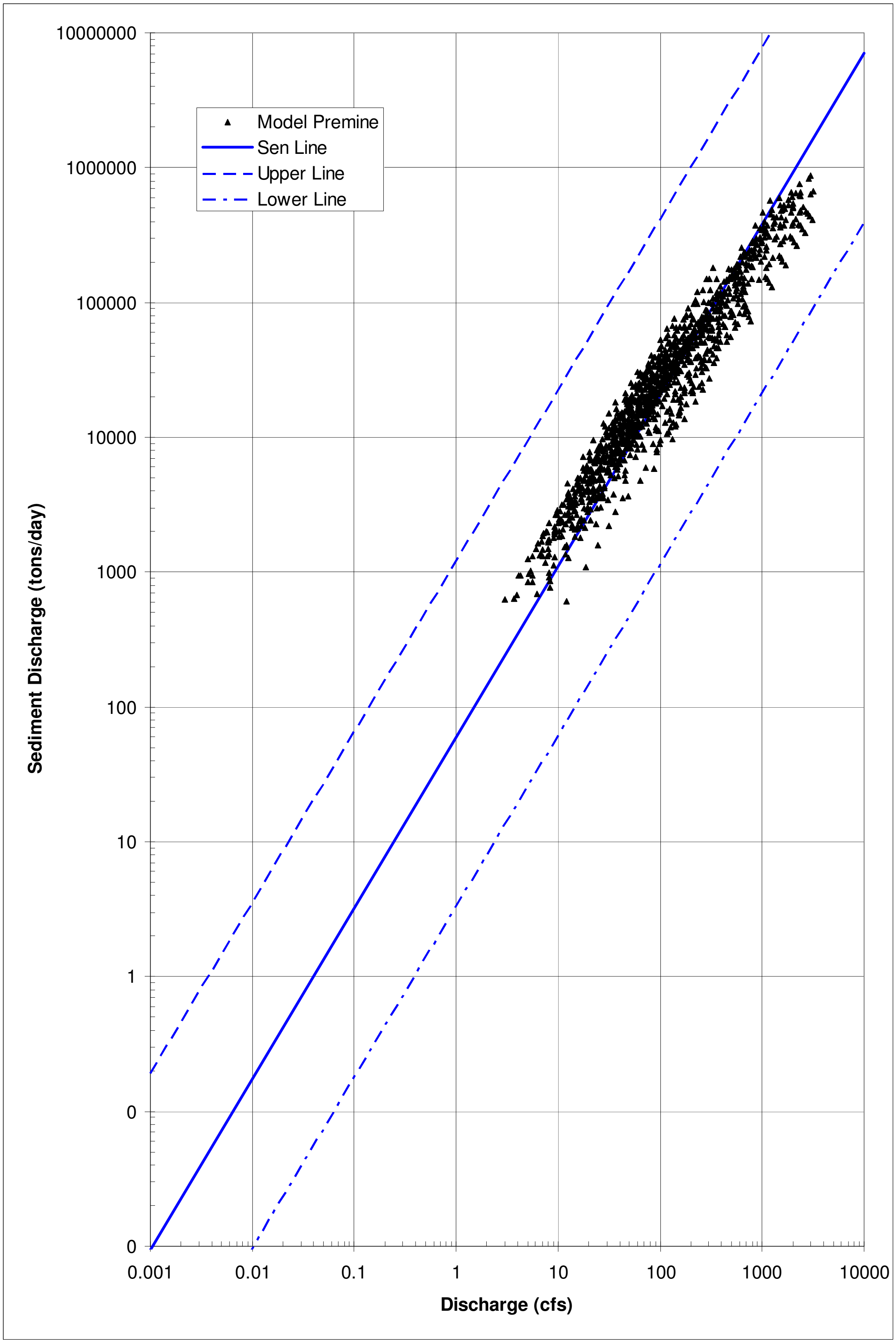

Figure 4.5. Modeled premine sediment and water discharge with Sen lines.

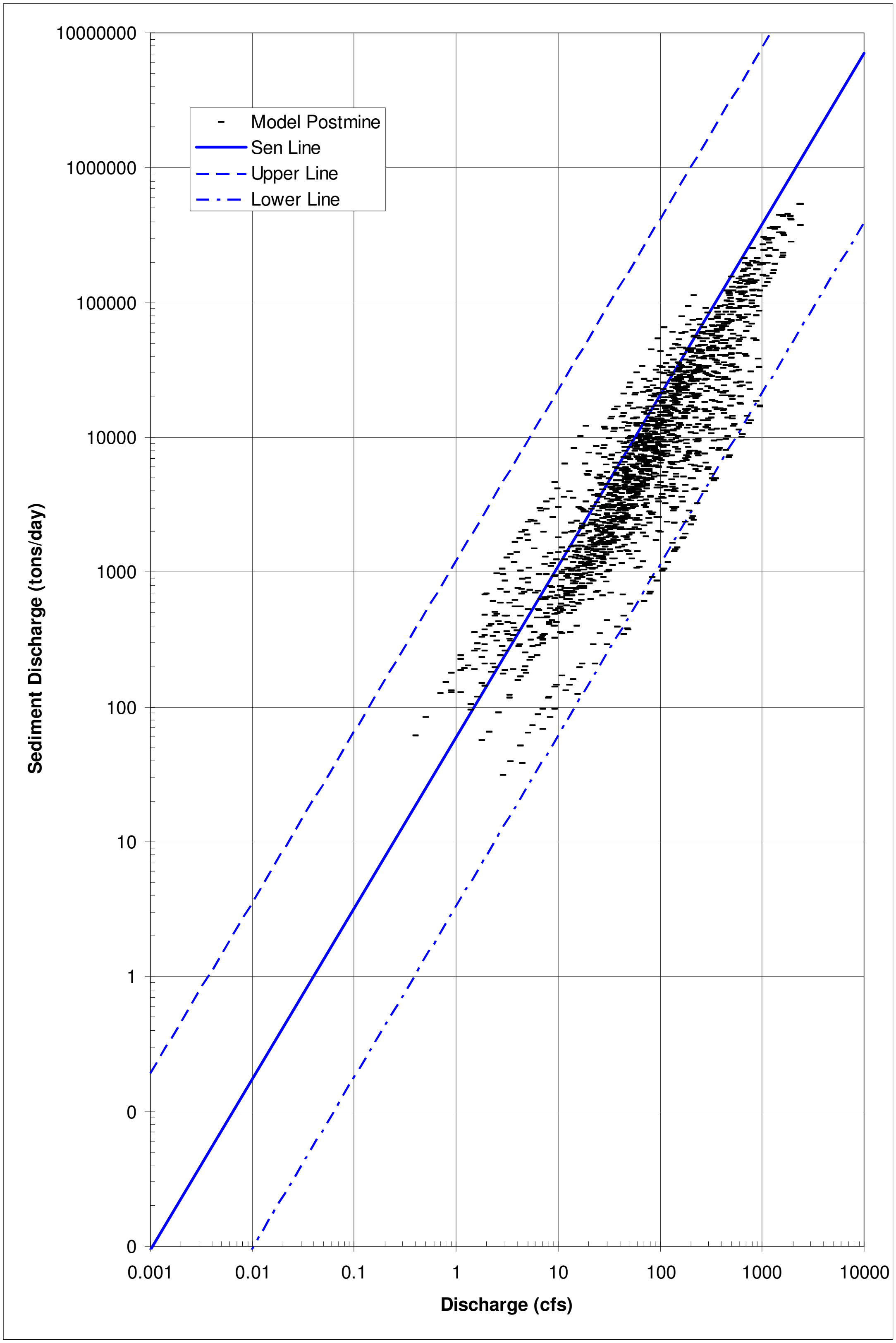

Figure 4.6. Modeled postmine sediment and water discharge with Sen lines.

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EXHIBIT 1

Postmine Topography

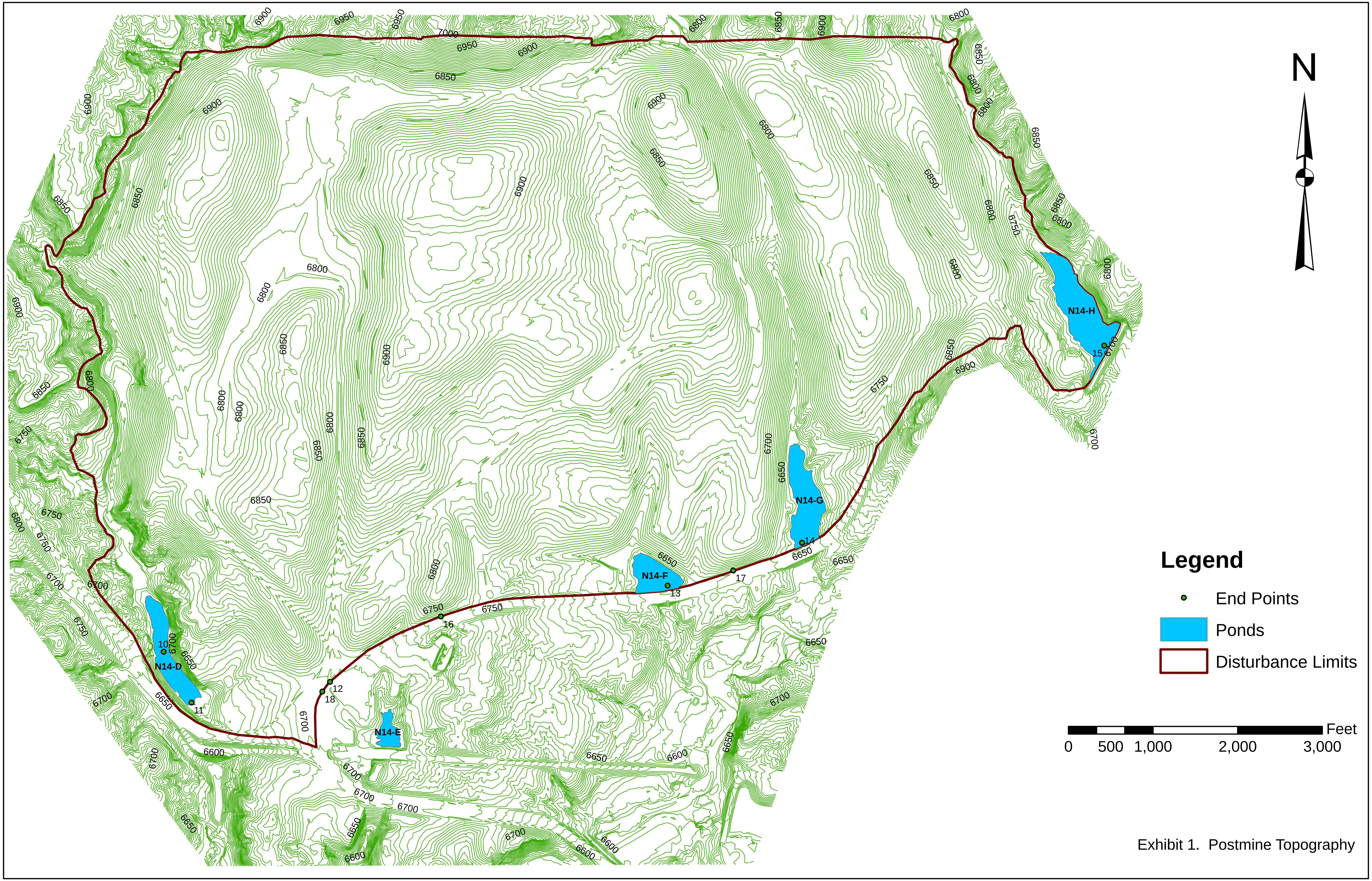


Exhibit 1. Postmine Topography

EXHIBIT 2

Premine Topography

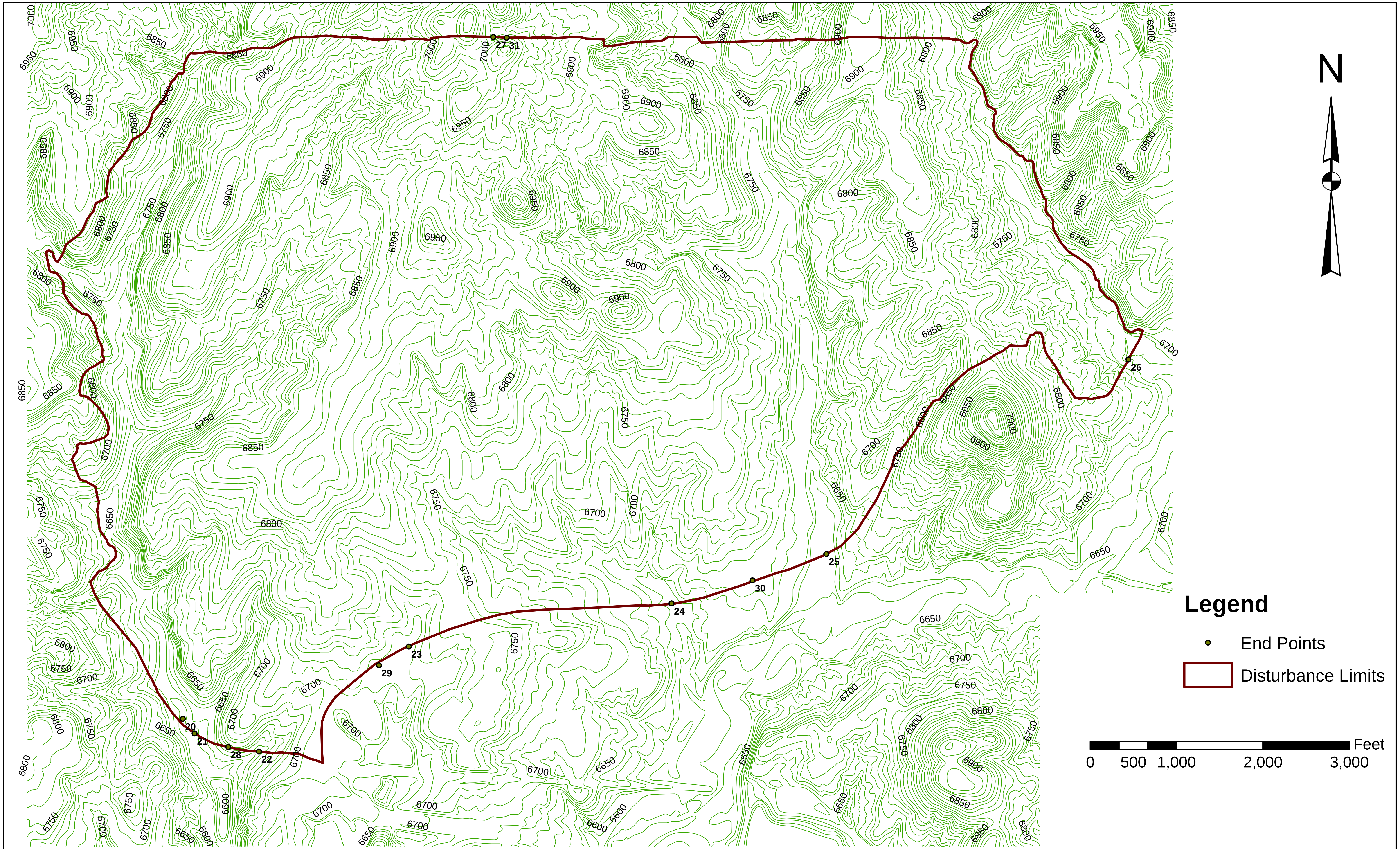


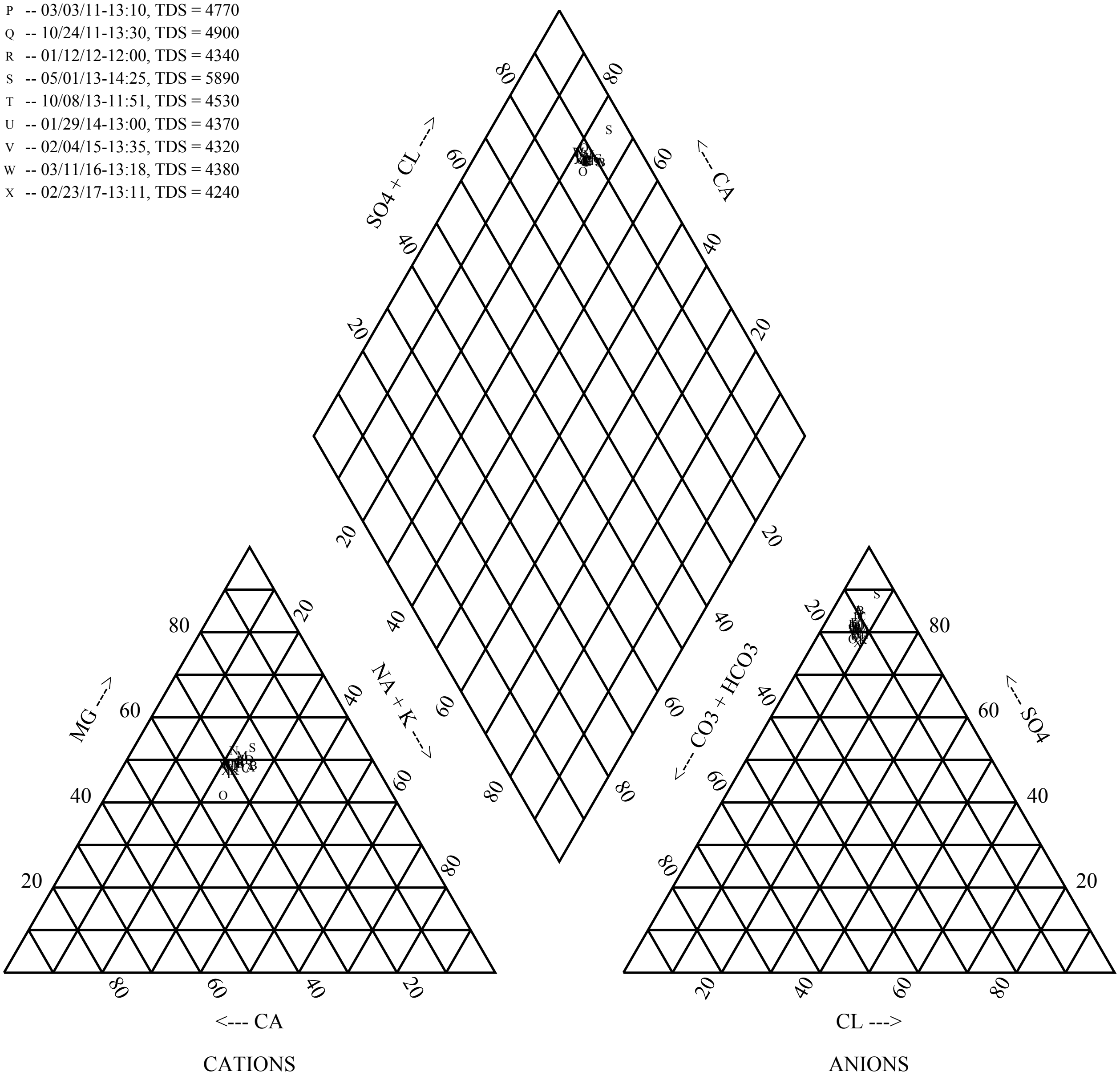
Exhibit 2. Premine Topography

Attachment 3-6

Trilinear Diagrams for Small Watershed Sites, Main Channel SW Monitoring Sites, Baseflow Sites, and Pond N14-F

SW2A

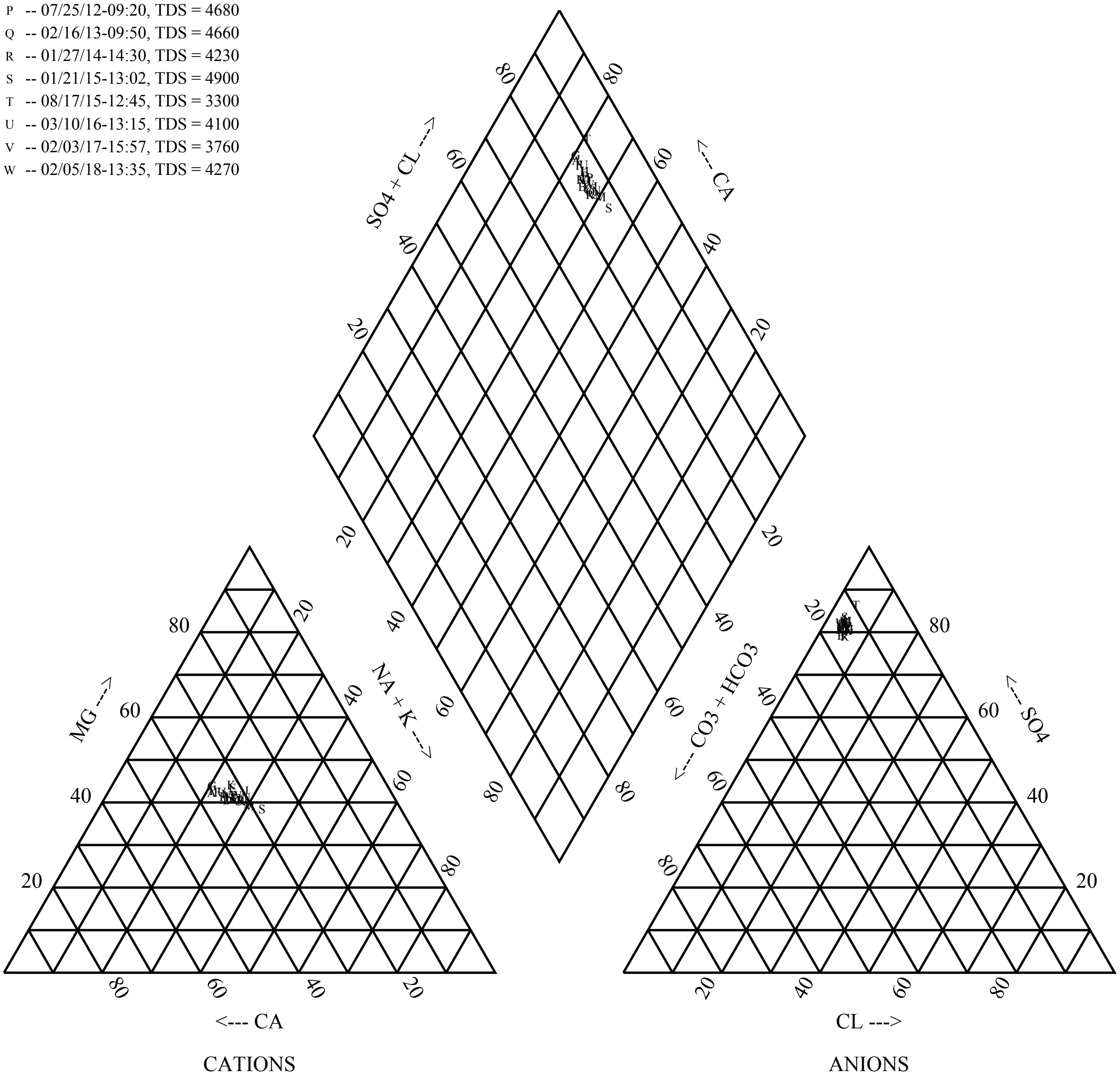
A -- 03/24/04-11:33, TDS = 7070
B -- 06/03/04-13:55, TDS = 6940
C -- 10/01/04-09:10, TDS = 6160
D -- 01/27/05-12:30, TDS = 5520
E -- 04/15/05-09:05, TDS = 5340
F -- 12/20/05-11:15, TDS = 5150
G -- 02/10/06-10:40, TDS = 5040
H -- 04/07/06-12:17, TDS = 5200
I -- 03/12/07-11:30, TDS = 5320
J -- 04/04/08-10:14, TDS = 5640
K -- 10/16/08-13:48, TDS = 6190
L -- 02/04/09-12:15, TDS = 5350
M -- 04/02/09-12:40, TDS = 5120
N -- 03/26/10-10:10, TDS = 4910
O -- 10/11/10-11:11, TDS = 4330
P -- 03/03/11-13:10, TDS = 4770
Q -- 10/24/11-13:30, TDS = 4900
R -- 01/12/12-12:00, TDS = 4340
S -- 05/01/13-14:25, TDS = 5890
T -- 10/08/13-11:51, TDS = 4530
U -- 01/29/14-13:00, TDS = 4370
V -- 02/04/15-13:35, TDS = 4320
W -- 03/11/16-13:18, TDS = 4380
X -- 02/23/17-13:11, TDS = 4240



Percent Of Total Milliequivalents Per Liter

SW80R

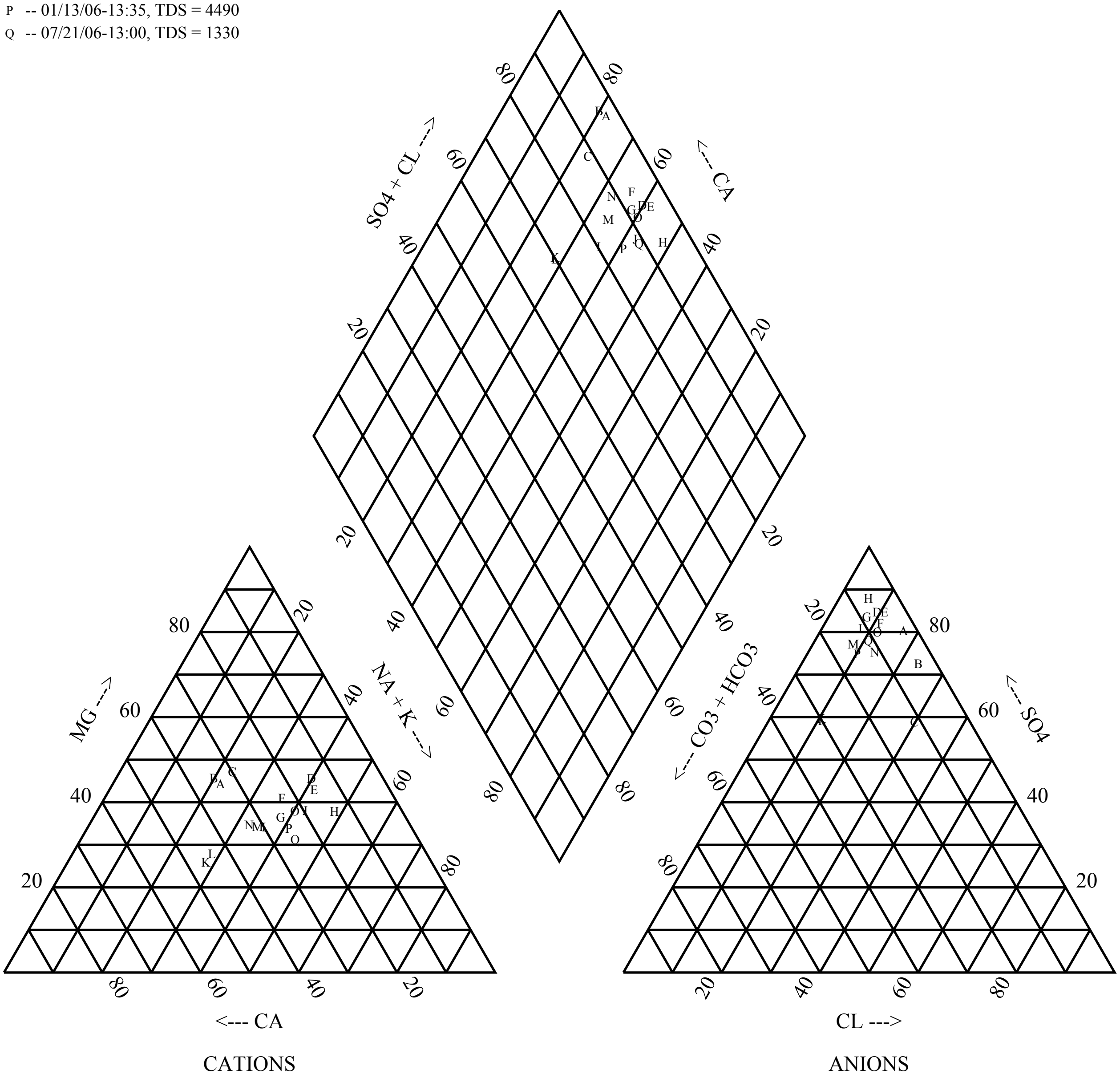
A -- 07/28/05-09:45, TDS = 4420
B -- 11/14/05-13:13, TDS = 4730
C -- 02/13/06-10:40, TDS = 4780
D -- 07/24/06-10:20, TDS = 4950
E -- 01/17/07-12:32, TDS = 4990
F -- 07/09/07-13:26, TDS = 4690
G -- 04/17/08-09:10, TDS = 4070
H -- 07/07/08-13:00, TDS = 4760
I -- 02/16/09-11:50, TDS = 4980
J -- 07/14/09-10:50, TDS = 5300
K -- 02/18/10-13:32, TDS = 4840
L -- 07/23/10-13:42, TDS = 5170
M -- 01/27/11-15:04, TDS = 5140
N -- 07/13/11-14:07, TDS = 5240
O -- 01/10/12-12:42, TDS = 4590
P -- 07/25/12-09:20, TDS = 4680
Q -- 02/16/13-09:50, TDS = 4660
R -- 01/27/14-14:30, TDS = 4230
S -- 01/21/15-13:02, TDS = 4900
T -- 08/17/15-12:45, TDS = 3300
U -- 03/10/16-13:15, TDS = 4100
V -- 02/03/17-15:57, TDS = 3760
W -- 02/05/18-13:35, TDS = 4270



Percent Of Total Milliequivalents Per Liter

N14-F-P

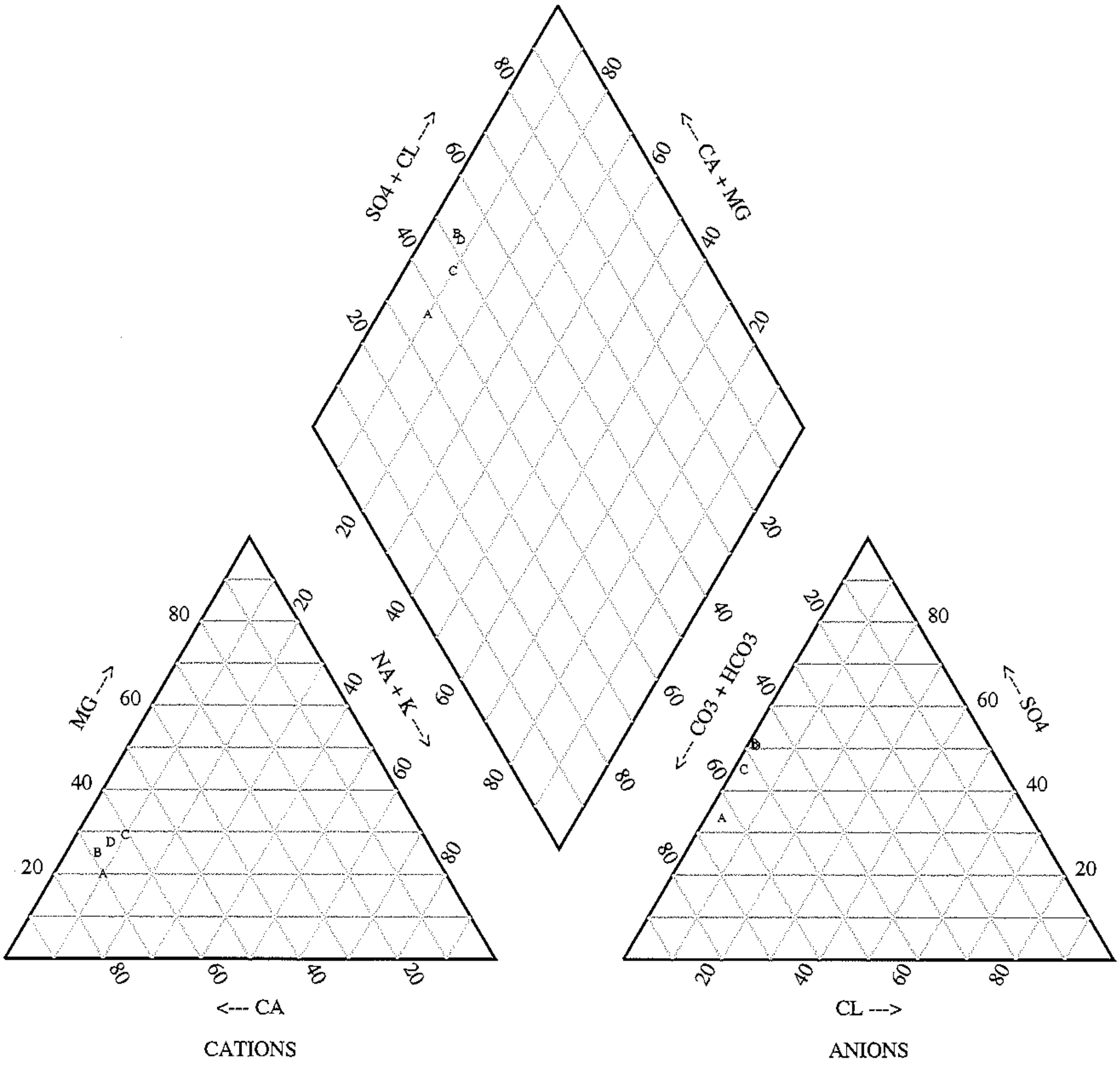
A -- 04/13/89-09:57, TDS = 2702
B -- 09/18/90-09:30, TDS = 3472
C -- 06/11/91-15:25, TDS = 3886
D -- 09/15/00-09:12, TDS = 13600
E -- 01/26/01-10:50, TDS = 5000
F -- 07/13/01-08:20, TDS = 5570
G -- 01/21/02-09:35, TDS = 9160
H -- 07/03/02-14:55, TDS = 12300
I -- 01/17/03-10:01, TDS = 1700
J -- 07/17/03-11:40, TDS = 7610
K -- 12/04/03-11:00, TDS = 440
L -- 02/09/04-11:49, TDS = 580
M -- 07/12/04-11:55, TDS = 2030
N -- 01/14/05-11:30, TDS = 1330
O -- 07/08/05-10:47, TDS = 4810
P -- 01/13/06-13:35, TDS = 4490
Q -- 07/21/06-13:00, TDS = 1330



Percent Of Total Milliequivalents Per Liter

FLUM227

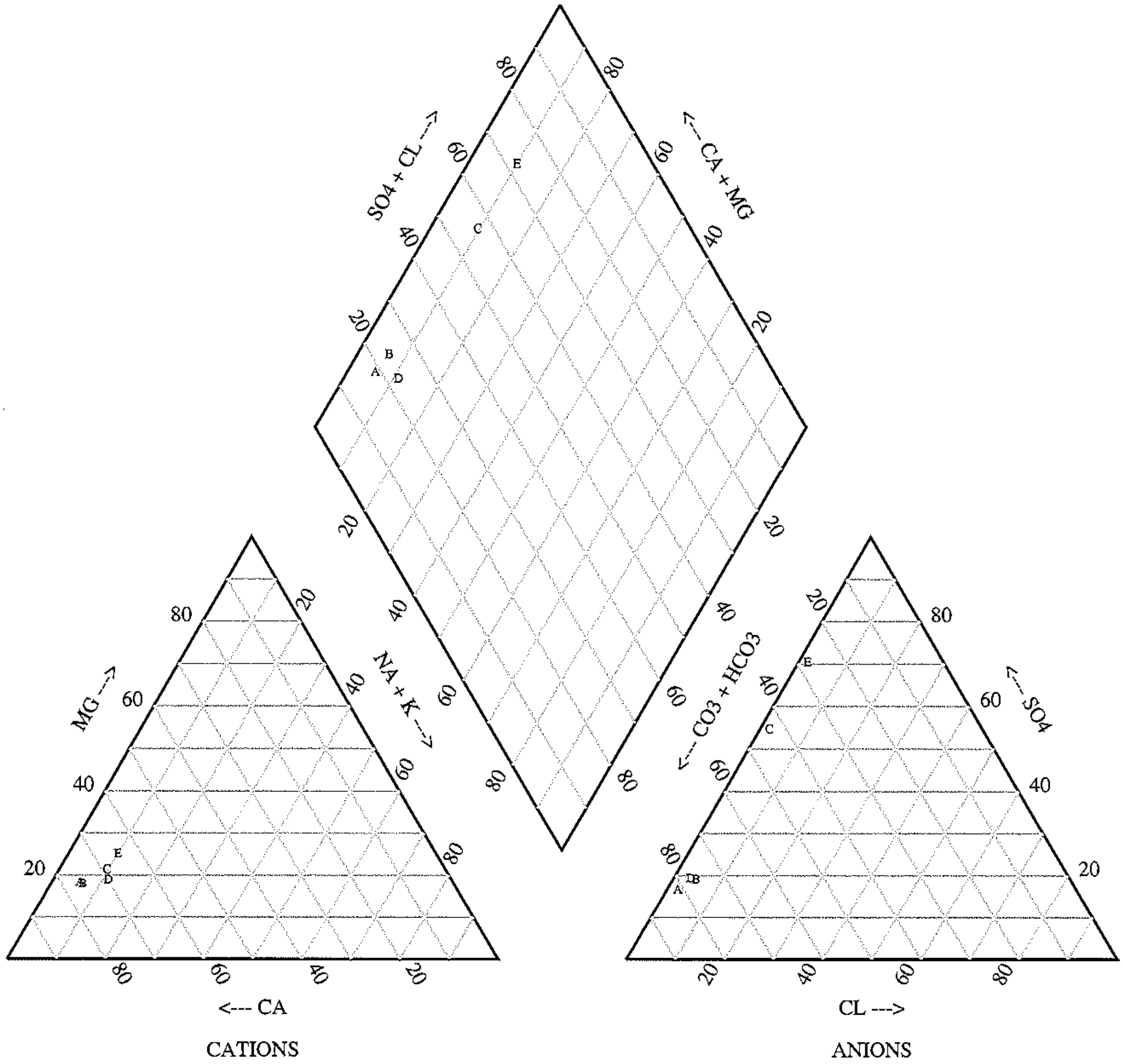
A -- 08/07/87-13:05, TDS = 190
B -- 02/10/88-13:37, TDS = 156
C -- 09/20/90-10:35, TDS = 74
D -- 08/06/91-08:37, TDS = 108



Percent Of Total Milliequivalents Per Liter

FLUM228

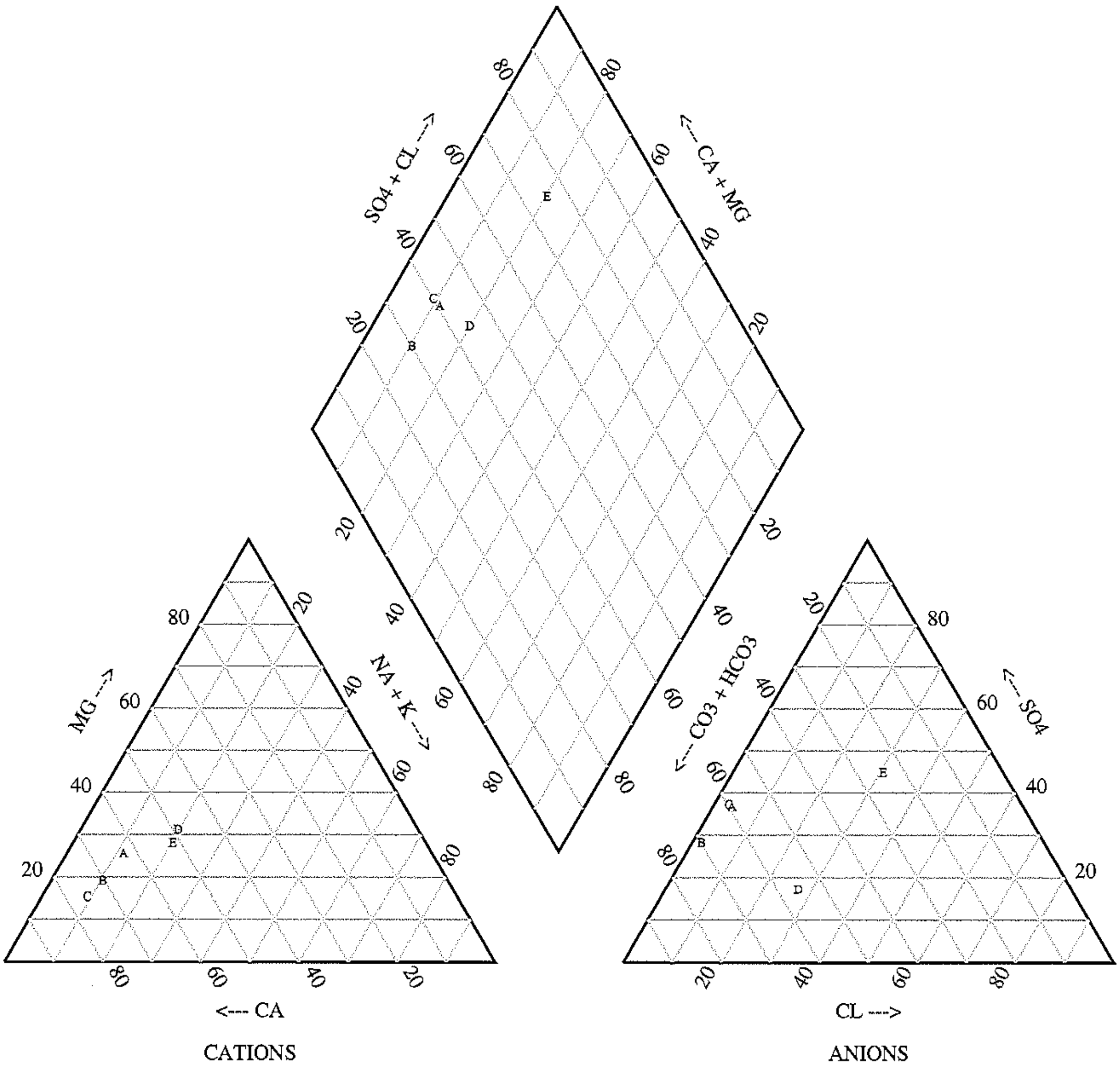
A -- 08/20/87-20:00, TDS = 120
B -- 08/26/88-13:05, TDS = 150
C -- 08/16/89-00:00, TDS = 94
D -- 09/20/90-10:32, TDS = 42
E -- 08/06/91-08:43, TDS = 240



Percent Of Total Milliequivalents Per Liter

FLUM267

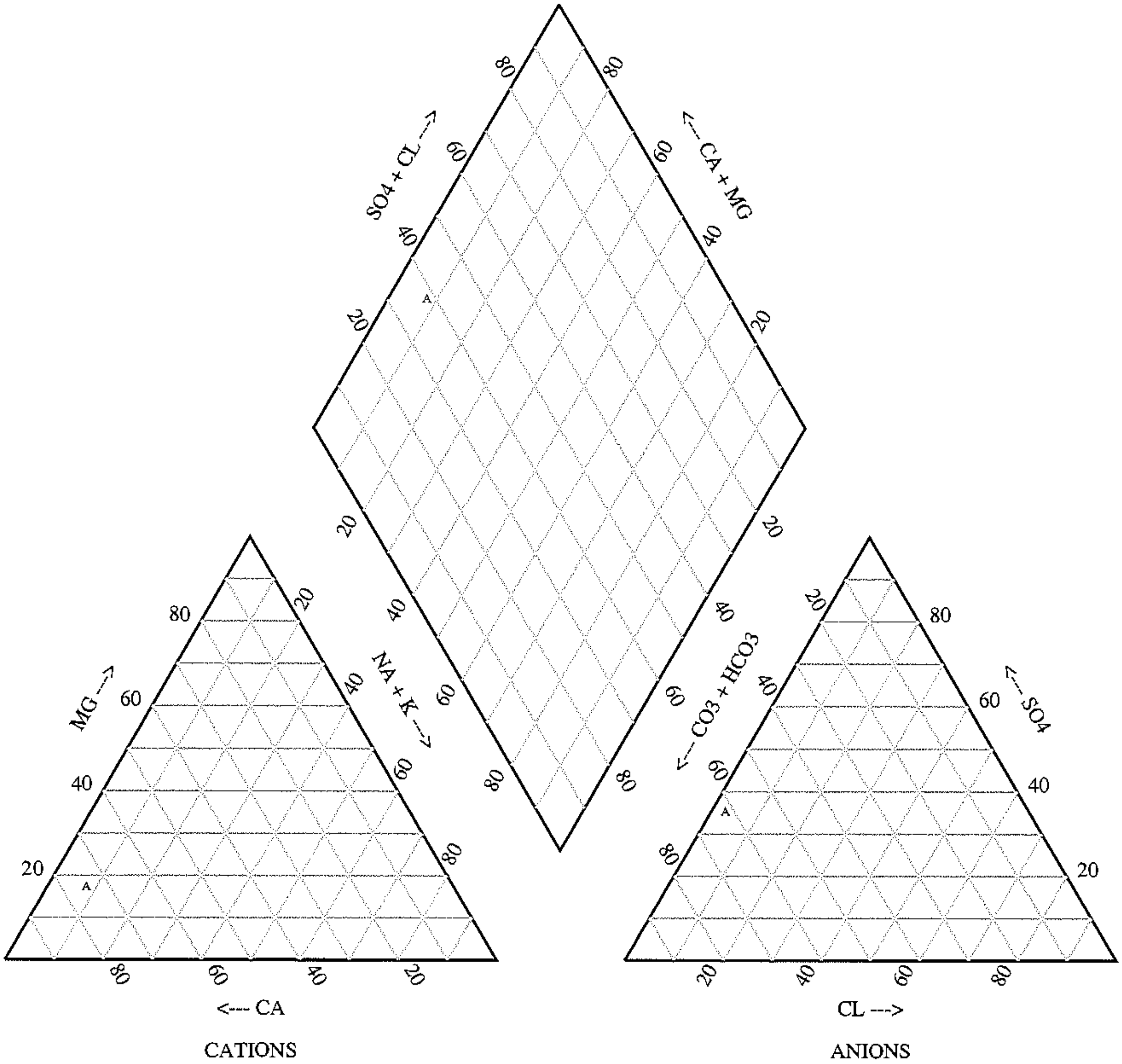
A -- 07/21/86-17:05, TDS = 200
B -- 08/29/86-13:02, TDS = 198
C -- 08/30/88-13:35, TDS = 100
D -- 08/15/89-00:00, TDS = 162
E -- 08/16/89-00:00, TDS = 196



Percent Of Total Milliequivalents Per Liter

FLUM268

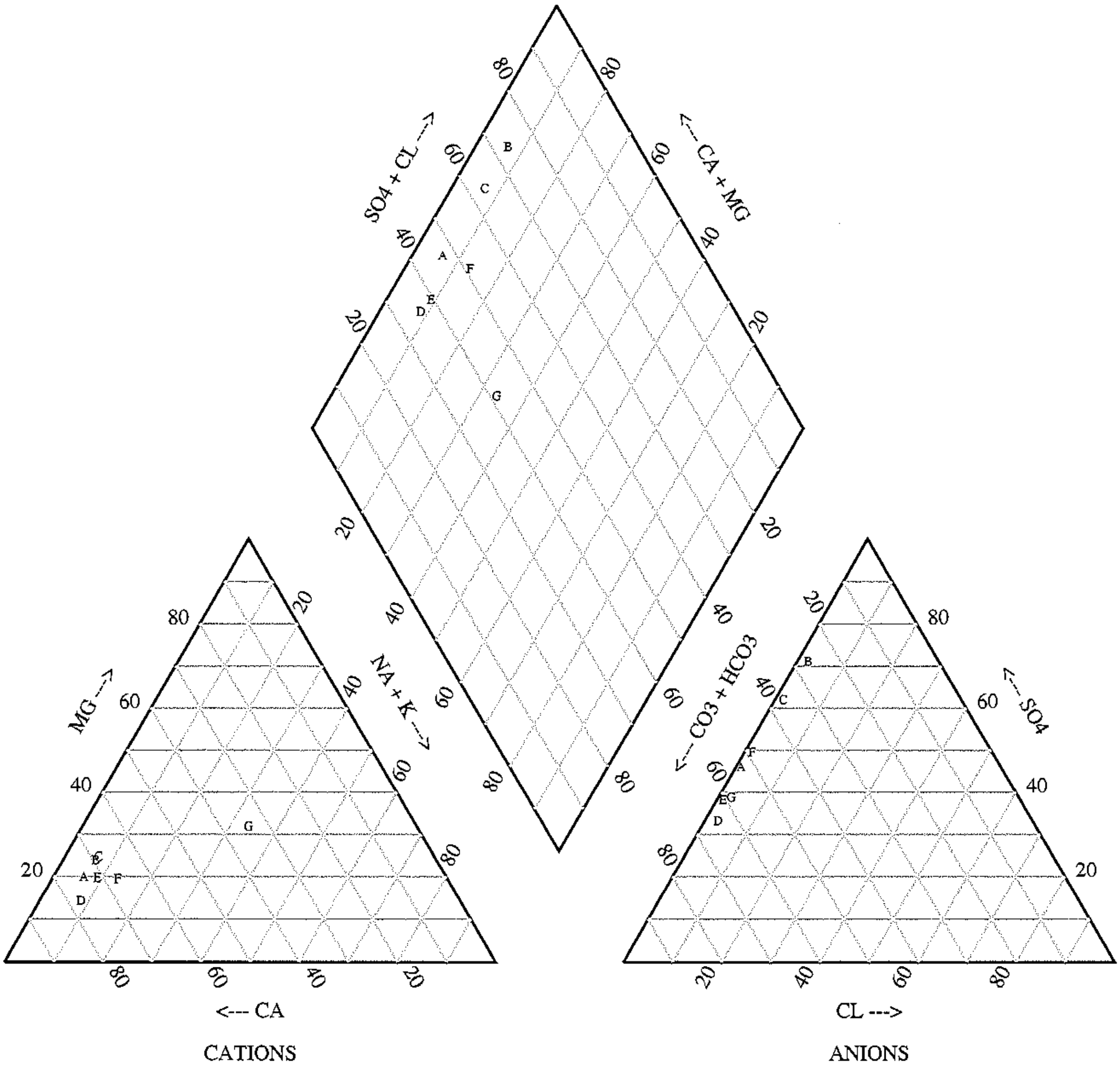
A -- 08/30/88-13:50, TDS = 125



Percent Of Total Milliequivalents Per Liter

FLUM277

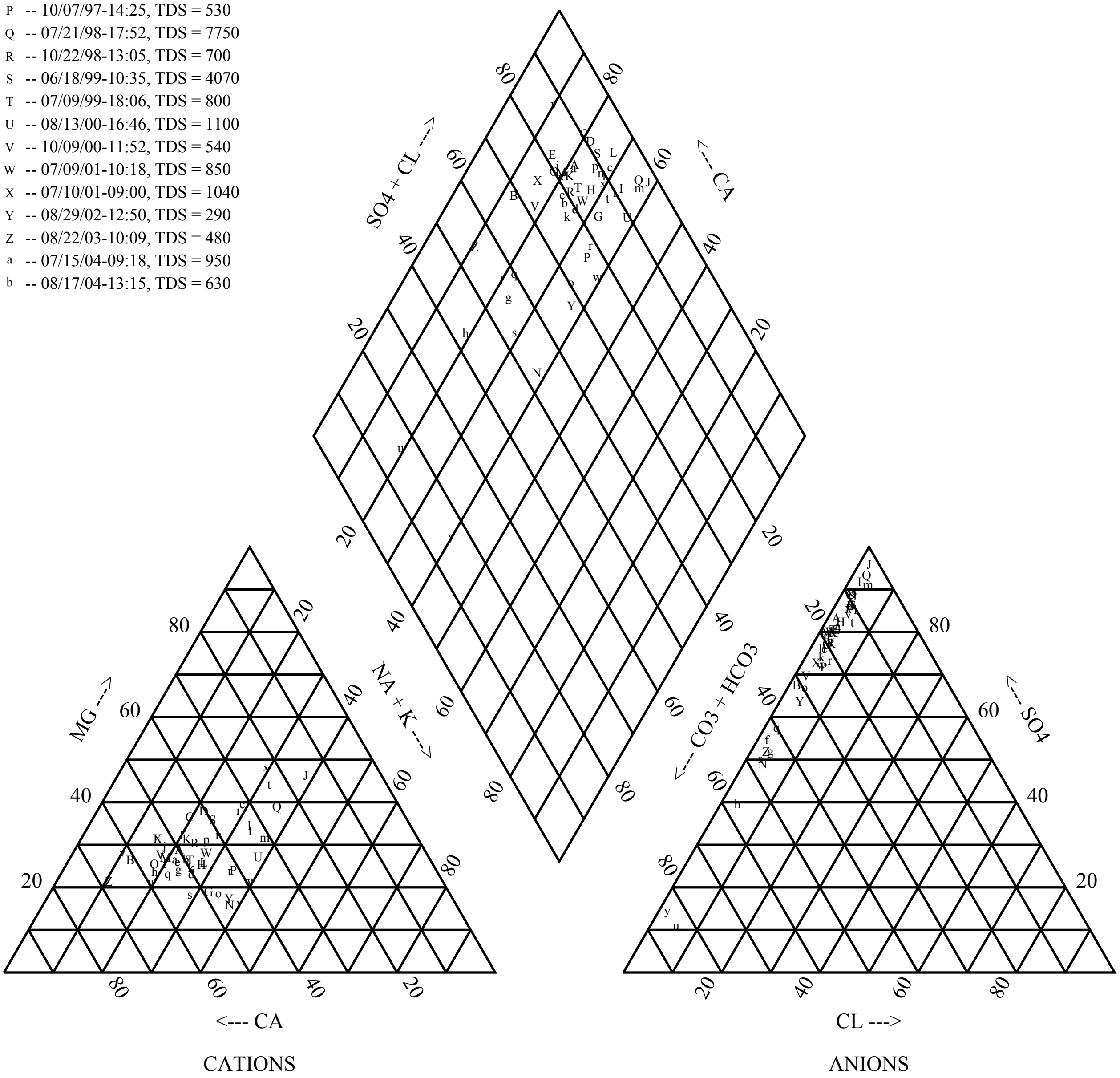
A -- 09/09/86-14:14, TDS = 244
B -- 08/26/87-13:51, TDS = 320
C -- 08/26/88-11:47, TDS = 245
D -- 10/06/89-11:30, TDS = 134
E -- 07/14/90-00:55, TDS = 176
F -- 09/04/90-14:44, TDS = 136
G -- 09/20/90-10:55, TDS = 64



Percent Of Total Milliequivalents Per Liter

SW25

A -- 07/19/86-14:30, TDS = 960
B -- 08/27/86-17:00, TDS = 690
C -- 08/25/87-11:00, TDS = 2850
D -- 10/30/87-10:30, TDS = 2040
E -- 08/25/88-13:00, TDS = 990
F -- 09/12/88-11:15, TDS = 942
G -- 07/31/89-16:35, TDS = 446
H -- 09/18/90-14:12, TDS = 568
I -- 08/06/91-10:48, TDS = 1282
J -- 07/10/92-16:00, TDS = 5622
K -- 08/12/94-09:23, TDS = 750
L -- 07/13/95-15:51, TDS = 2210
M -- 09/29/95-11:17, TDS = 570
N -- 08/24/96-17:39, TDS = 200
O -- 07/30/97-09:40, TDS = 660
P -- 10/07/97-14:25, TDS = 530
Q -- 07/21/98-17:52, TDS = 7750
R -- 10/22/98-13:05, TDS = 700
S -- 06/18/99-10:35, TDS = 4070
T -- 07/09/99-18:06, TDS = 800
U -- 08/13/00-16:46, TDS = 1100
V -- 10/09/00-11:52, TDS = 540
W -- 07/09/01-10:18, TDS = 850
X -- 07/10/01-09:00, TDS = 1040
Y -- 08/29/02-12:50, TDS = 290
Z -- 08/22/03-10:09, TDS = 480
a -- 07/15/04-09:18, TDS = 950
b -- 08/17/04-13:15, TDS = 630
c -- 04/15/05-12:10, TDS = 5190
d -- 07/25/05-15:16, TDS = 620
e -- 07/25/06-12:35, TDS = 580
f -- 07/31/06-08:50, TDS = 270
g -- 08/07/06-11:13, TDS = 350
h -- 08/24/06-14:40, TDS = 290
i -- 03/08/07-13:40, TDS = 4480
j -- 07/25/07-08:35, TDS = 660
k -- 07/30/07-12:58, TDS = 600
l -- 07/22/08-11:25, TDS = 4480
m -- 09/04/09-15:13, TDS = 2040
n -- 07/30/10-15:20, TDS = 2210
o -- 07/30/10-15:33, TDS = 620
p -- 08/15/11-13:03, TDS = 1550
q -- 08/02/12-20:04, TDS = 660
r -- 08/23/12-12:50, TDS = 570
s -- 07/19/13-15:35, TDS = 270
t -- 08/13/14-11:27, TDS = 4700
u -- 08/19/14-16:40, TDS = 630
v -- 07/08/15-19:47, TDS = 440
w -- 07/19/16-17:36, TDS = 1250
x -- 08/04/17-20:00, TDS = 6100
y -- 07/16/18-14:35, TDS = 2400



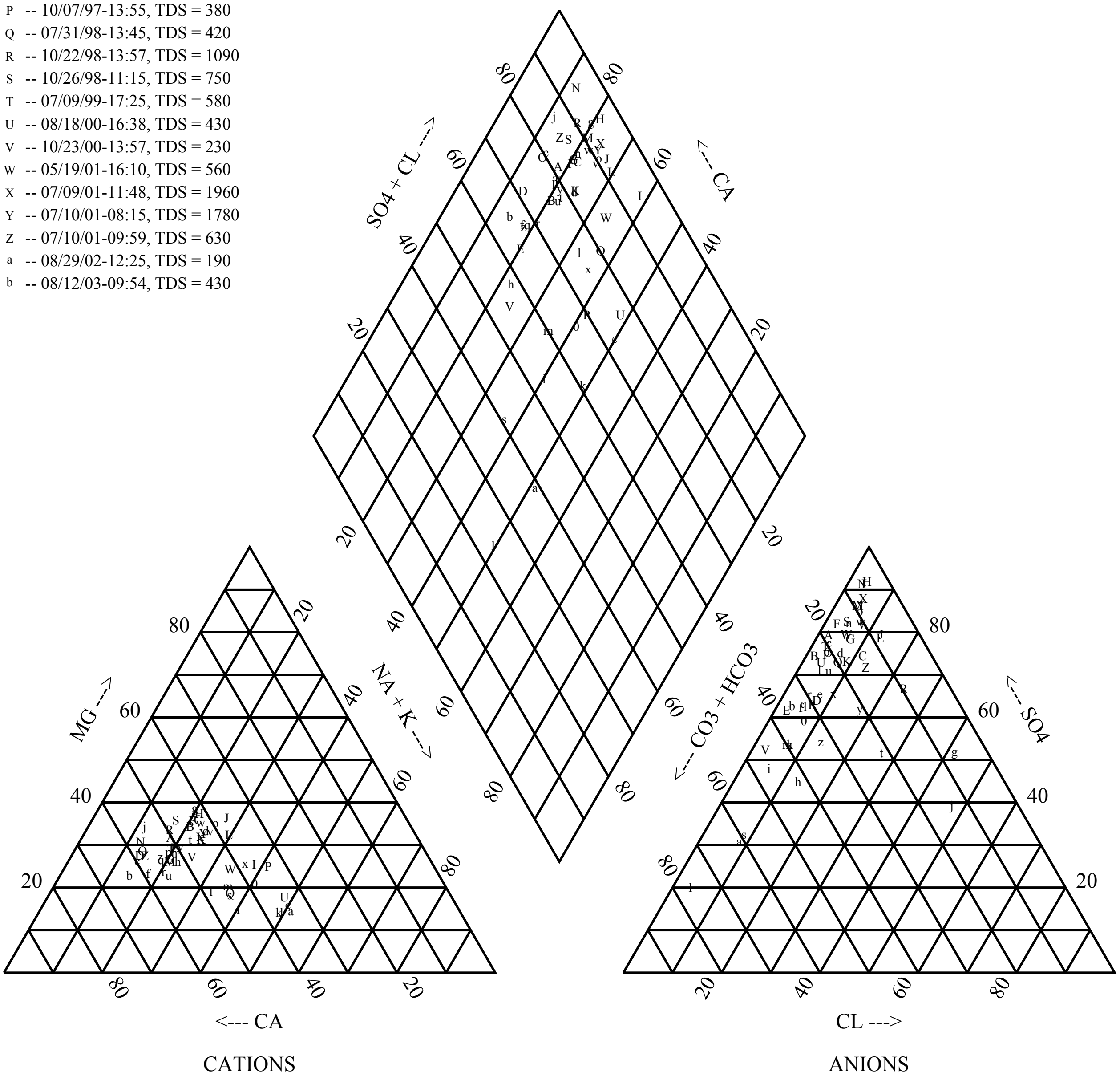
Percent Of Total Milliequivalents Per Liter

SW26

A -- 08/05/86-18:45, TDS = 1820
B -- 08/29/86-16:00, TDS = 1302
C -- 08/07/87-11:50, TDS = 1170
D -- 08/26/87-17:18, TDS = 570
E -- 08/26/88-13:45, TDS = 600
F -- 09/12/88-10:37, TDS = 1144
G -- 09/05/90-14:15, TDS = 572
H -- 07/24/91-16:12, TDS = 3635
I -- 07/10/92-16:21, TDS = 1512
J -- 08/11/94-16:18, TDS = 2628
K -- 08/19/94-14:23, TDS = 900
L -- 07/13/95-17:25, TDS = 1190
M -- 08/24/96-18:48, TDS = 1300
N -- 07/23/97-09:15, TDS = 2120
O -- 07/29/97-10:00, TDS = 490
P -- 10/07/97-13:55, TDS = 380
Q -- 07/31/98-13:45, TDS = 420
R -- 10/22/98-13:57, TDS = 1090
S -- 10/26/98-11:15, TDS = 750
T -- 07/09/99-17:25, TDS = 580
U -- 08/18/00-16:38, TDS = 430
V -- 10/23/00-13:57, TDS = 230
W -- 05/19/01-16:10, TDS = 560
X -- 07/09/01-11:48, TDS = 1960
Y -- 07/10/01-08:15, TDS = 1780
Z -- 07/10/01-09:59, TDS = 630
a -- 08/29/02-12:25, TDS = 190
b -- 08/12/03-09:54, TDS = 430

c -- 07/15/04-08:37, TDS = 400
d -- 02/25/05-11:55, TDS = 760
e -- 07/25/05-14:25, TDS = 380
f -- 08/08/05-15:45, TDS = 330
g -- 07/21/06-11:20, TDS = 1300
h -- 07/30/06-18:57, TDS = 300
i -- 07/27/07-16:35, TDS = 250
j -- 07/30/07-11:37, TDS = 770
k -- 08/15/07-14:50, TDS = 220
l -- 08/06/08-14:20, TDS = 360
m -- 09/04/09-14:24, TDS = 360
n -- 07/29/10-12:15, TDS = 900

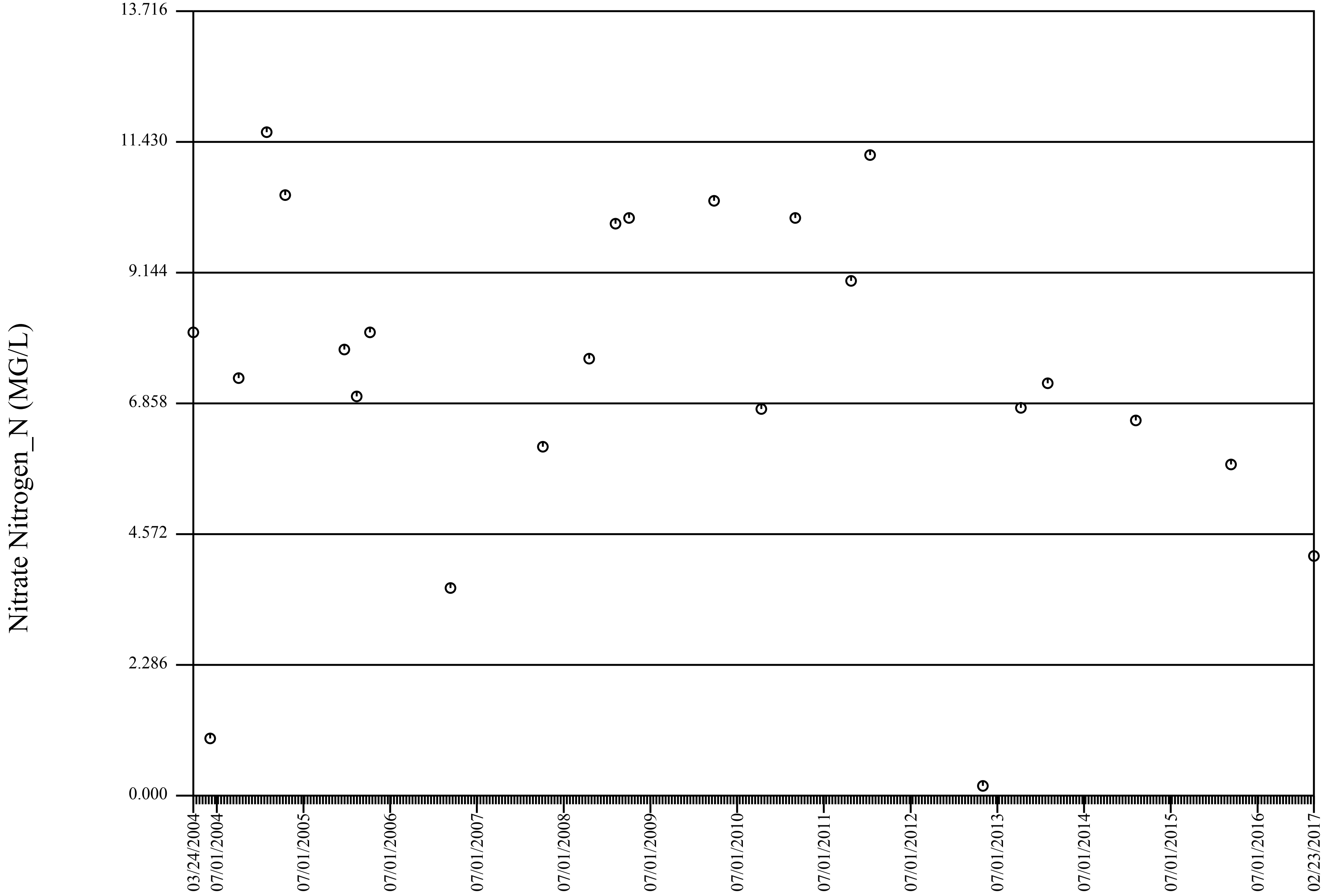
o -- 07/29/10-18:25, TDS = 2570
p -- 07/26/11-13:25, TDS = 540
q -- 07/26/11-18:50, TDS = 390
r -- 07/31/12-17:10, TDS = 350
s -- 08/17/12-18:10, TDS = 250
t -- 08/23/12-12:10, TDS = 430
u -- 07/19/13-16:05, TDS = 340
v -- 08/13/14-10:12, TDS = 1660
w -- 08/19/14-16:17, TDS = 2600
x -- 08/11/15-16:42, TDS = 570
y -- 08/01/16-19:06, TDS = 1400
z -- 08/04/16-14:46, TDS = 900
0 -- 08/04/17-15:01, TDS = 480
1 -- 07/12/18-14:06, TDS = 2300



Percent Of Total Milliequivalents Per Liter

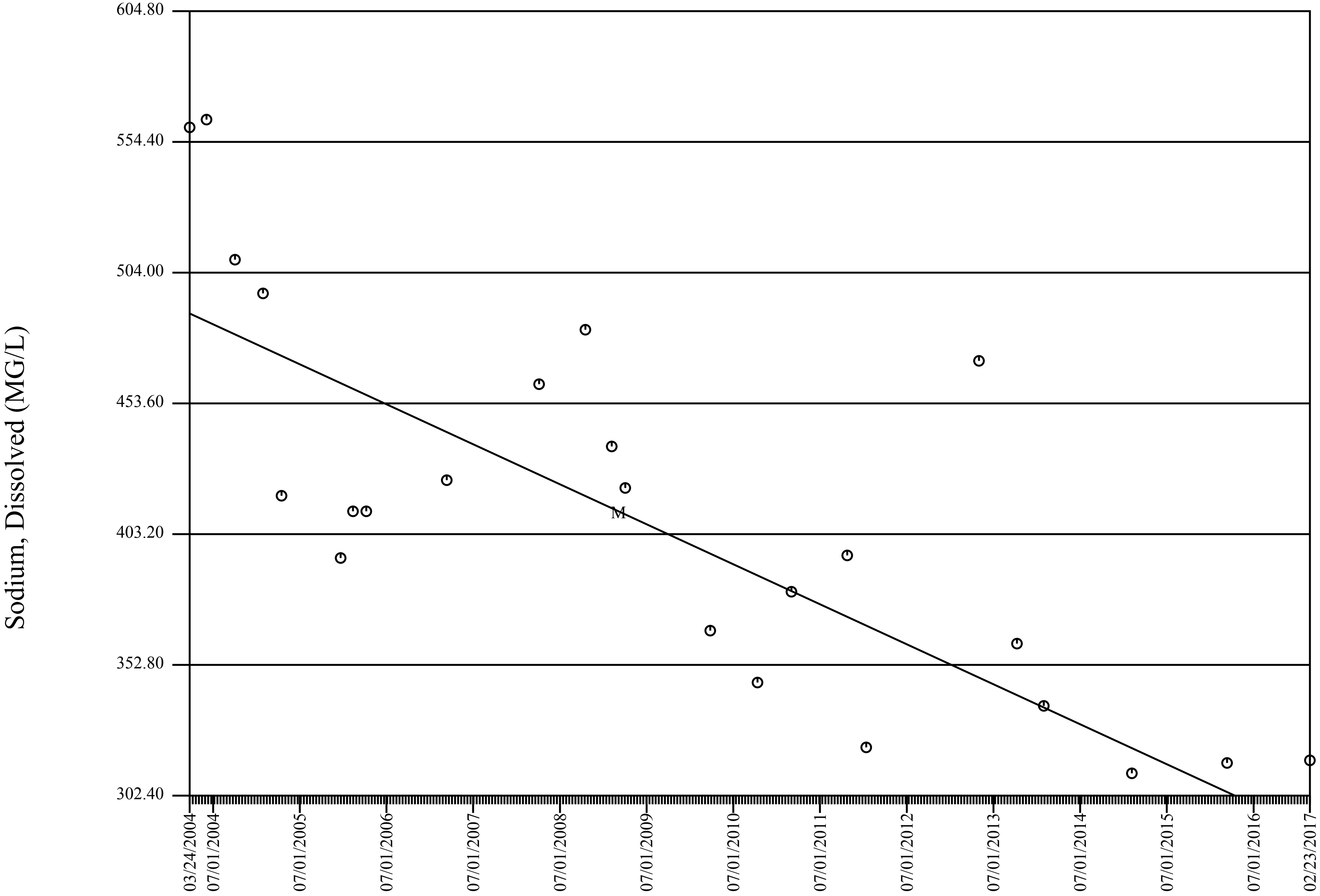
Attachment 3-7

Sen Estimate of Trend Slope Plots for Main Channel SW Monitoring Sites
and Baseflow Sites Proximate to J-1/N-6, J-16 and N-14 TOJ Parcels



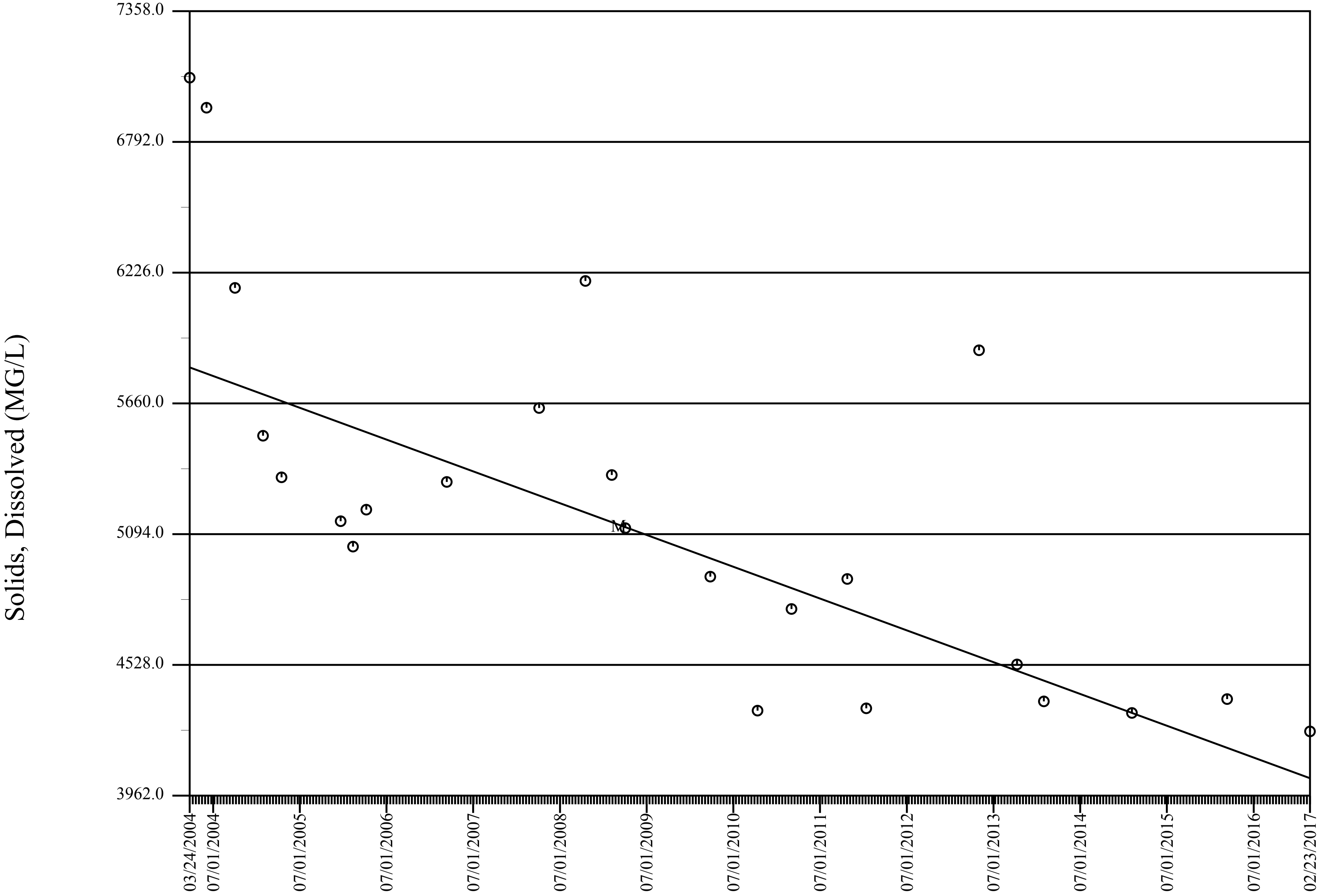
No censored data. No trend detected at 10.00%

SW2A



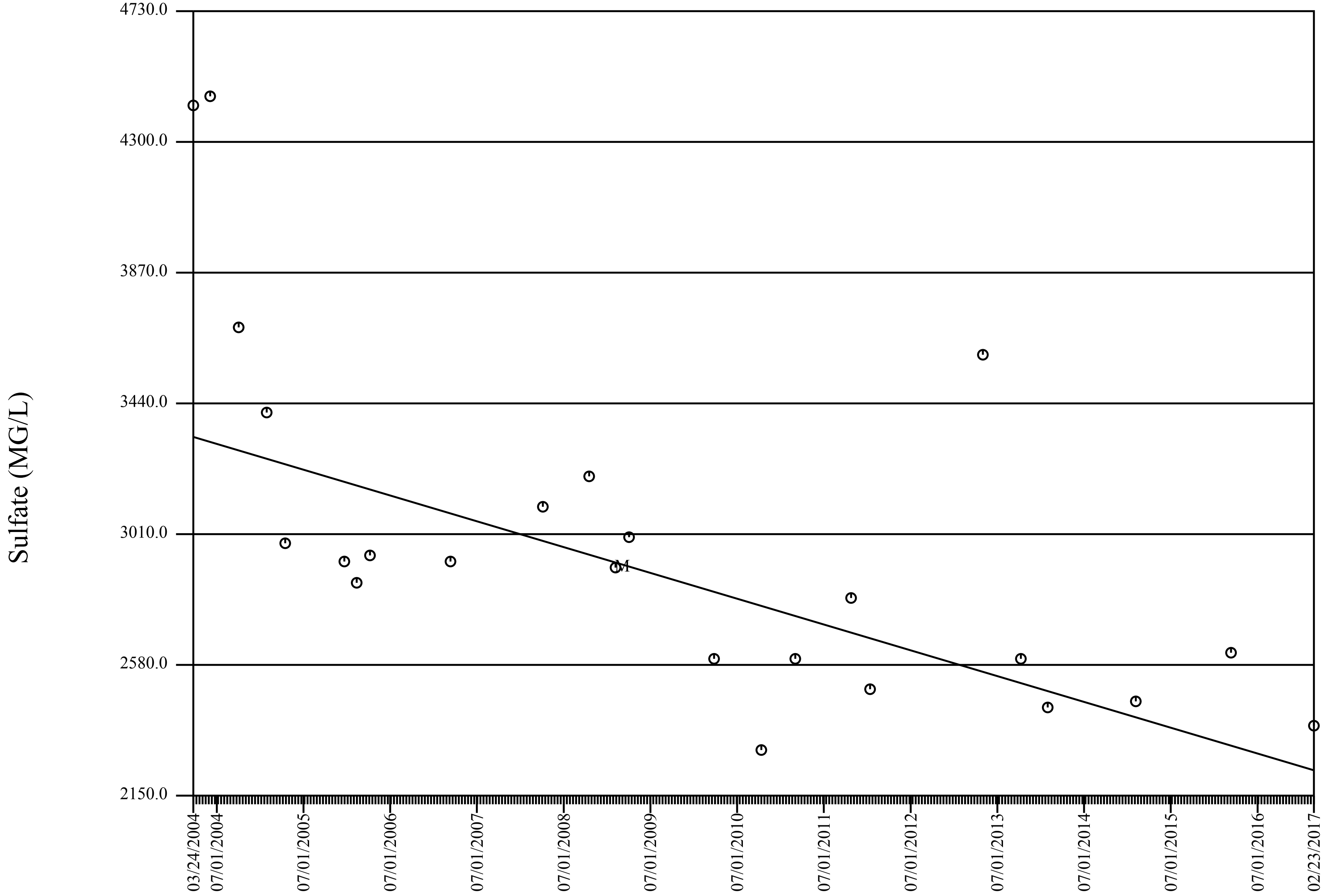
No censored data. -0.0422 Sen trend detected at 10.00% in 90.00% confidence interval -0.0544, -0.0284

SW2A



No censored data. -0.3769 Sen trend detected at 10.00% in 90.00% confidence interval -0.5280, -0.2649

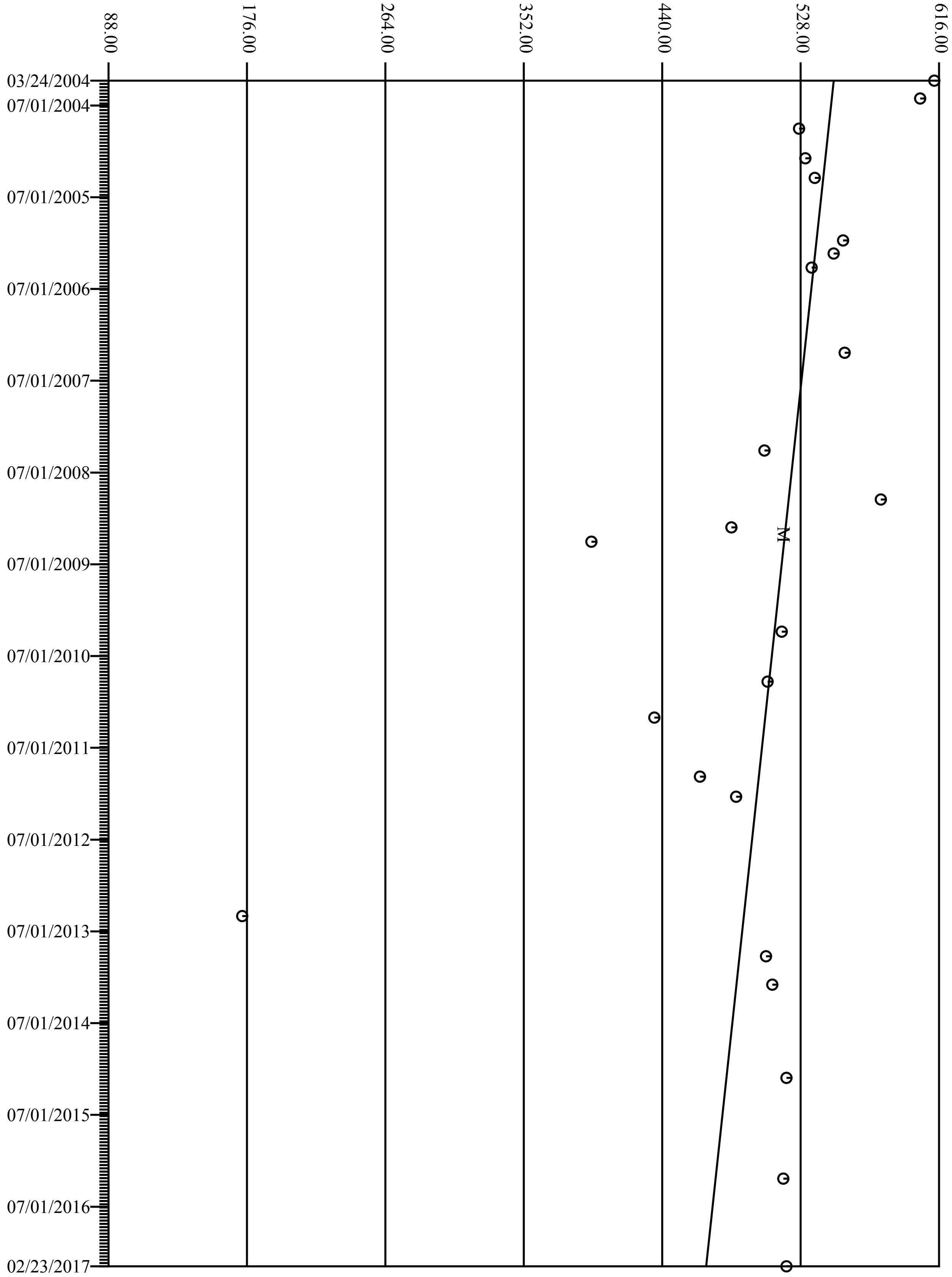
SW2A



No censored data. -0.2323 Sen trend detected at 10.00% in 90.00% confidence interval -0.3327, -0.1481

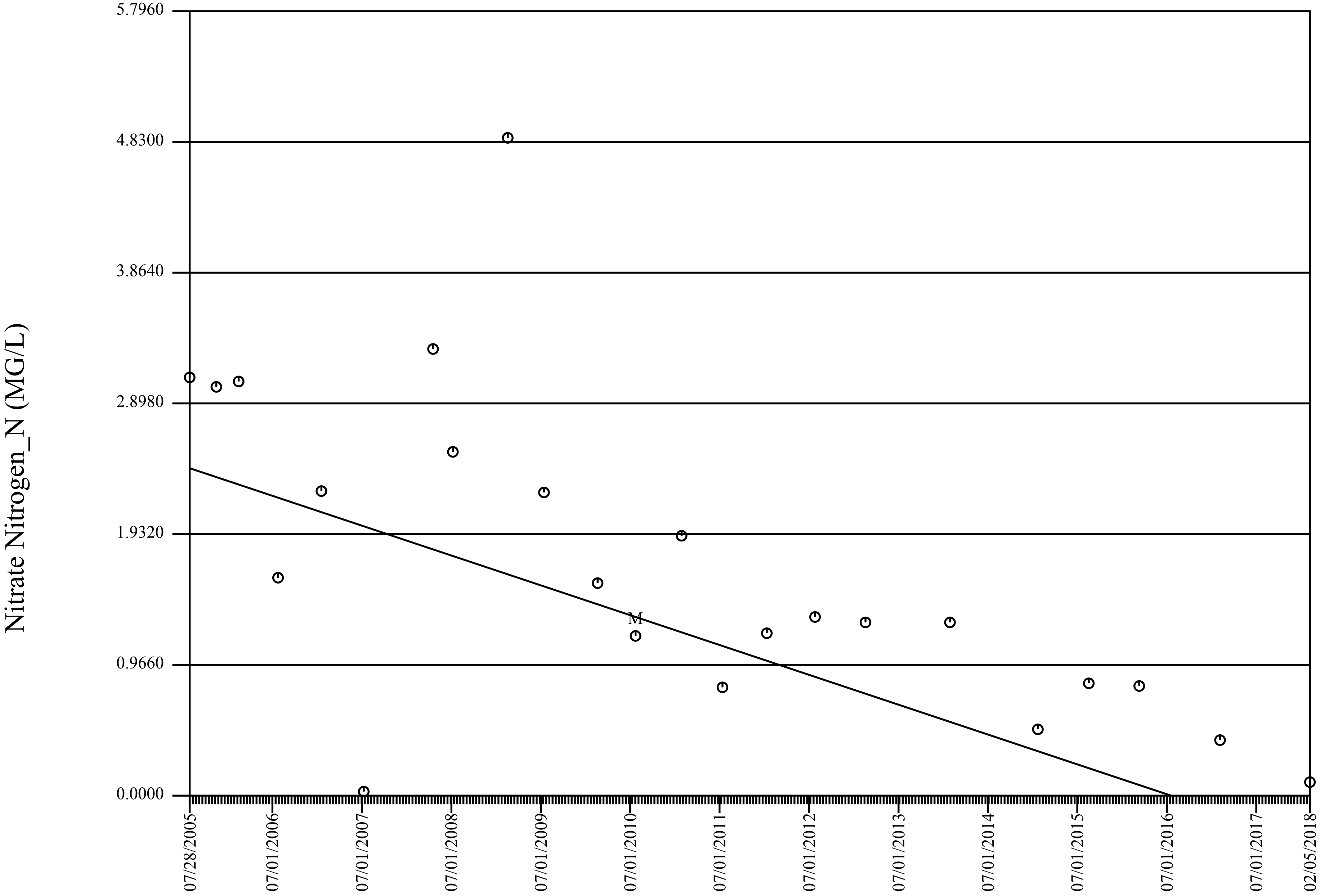
SW2A

Bicarbonate As HCO3 (MG/L)



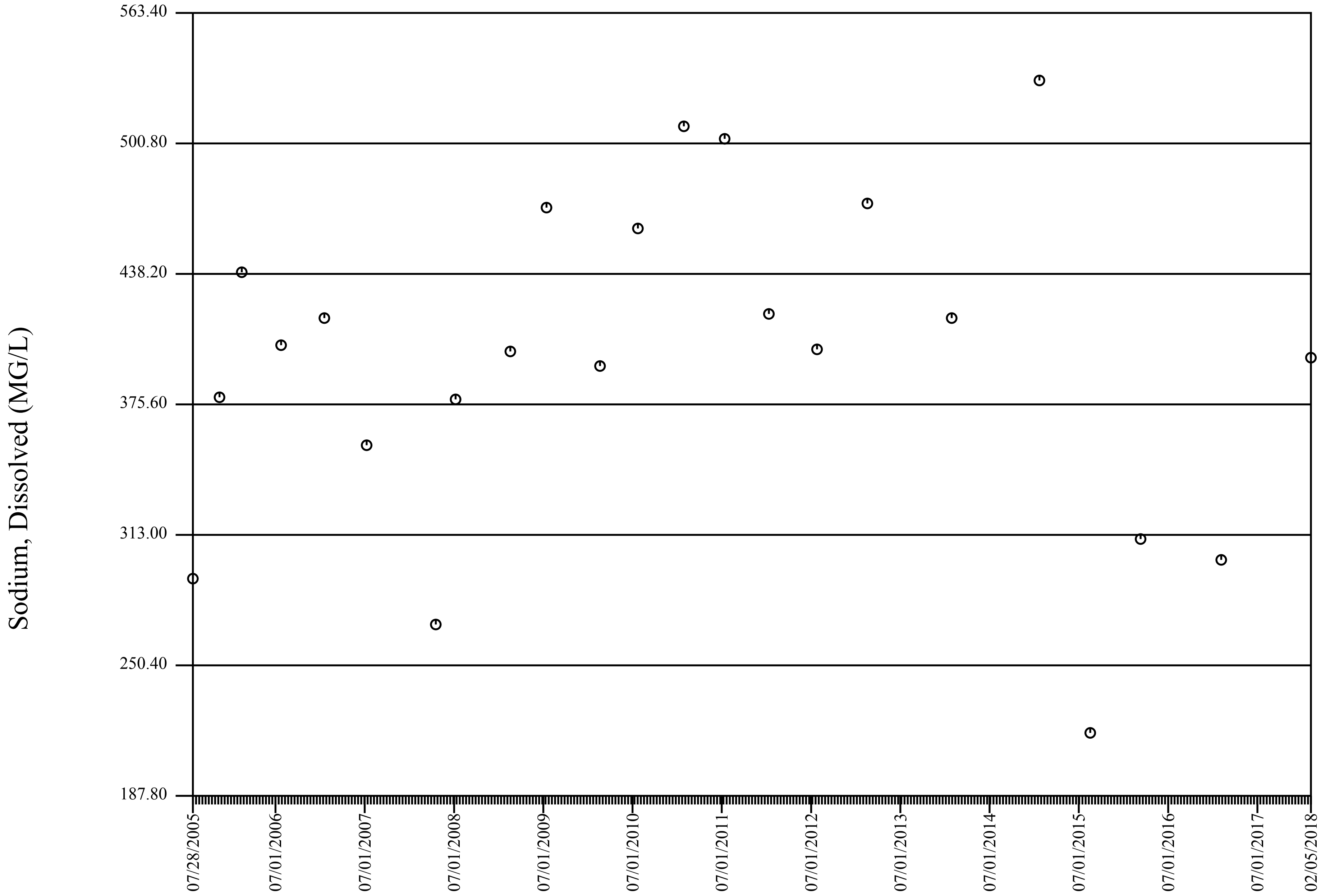
No censored data. -0.0172 Sen trend detected at 10.00% in 90.00% confidence interval -0.0316, -0.0050

SW2A



No censored data. -0.0006 Sen trend detected at 10.00% in 90.00% confidence interval -0.0007, -0.0004

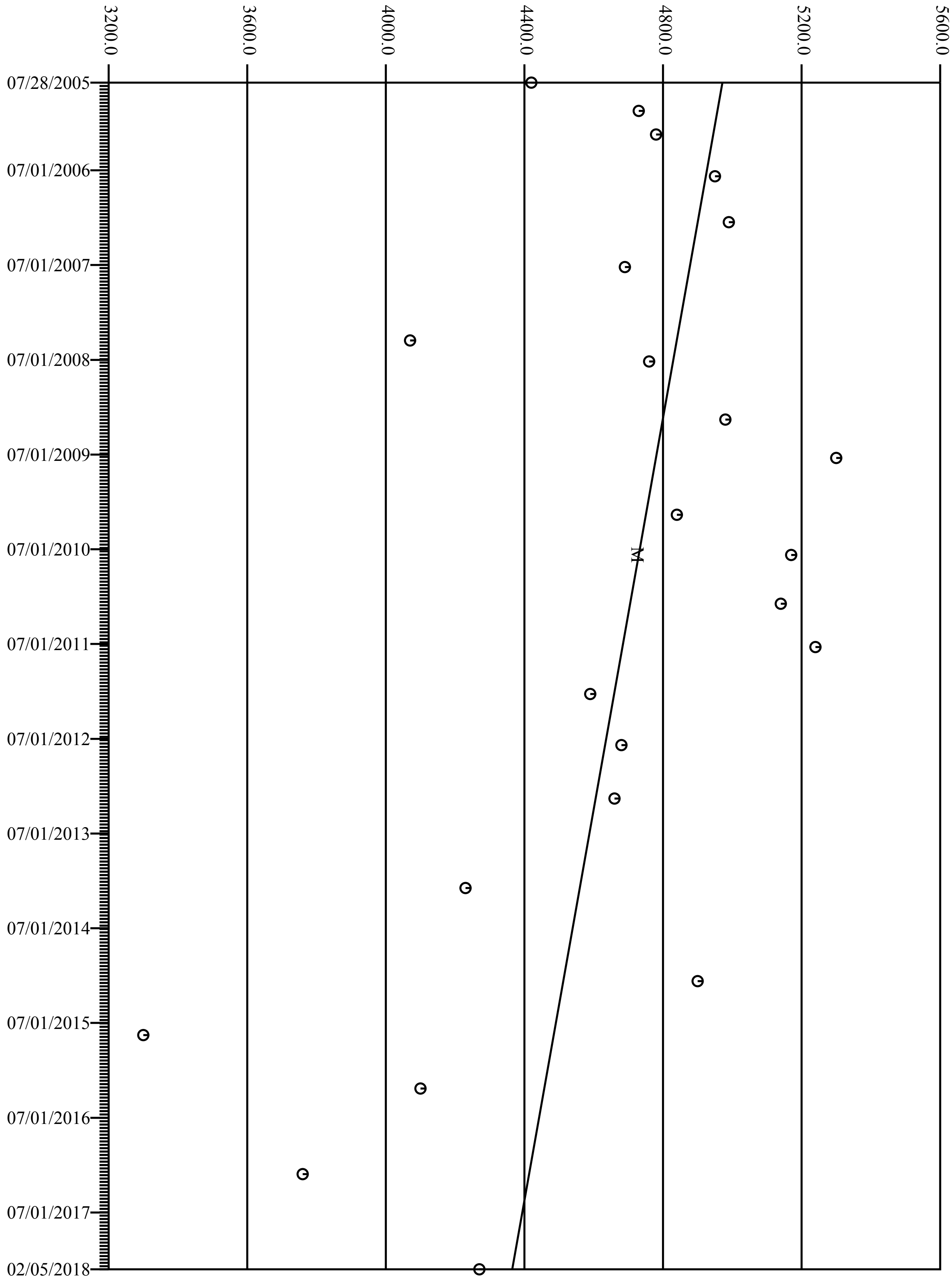
SW80R



No censored data. No trend detected at 10.00%

SW80R

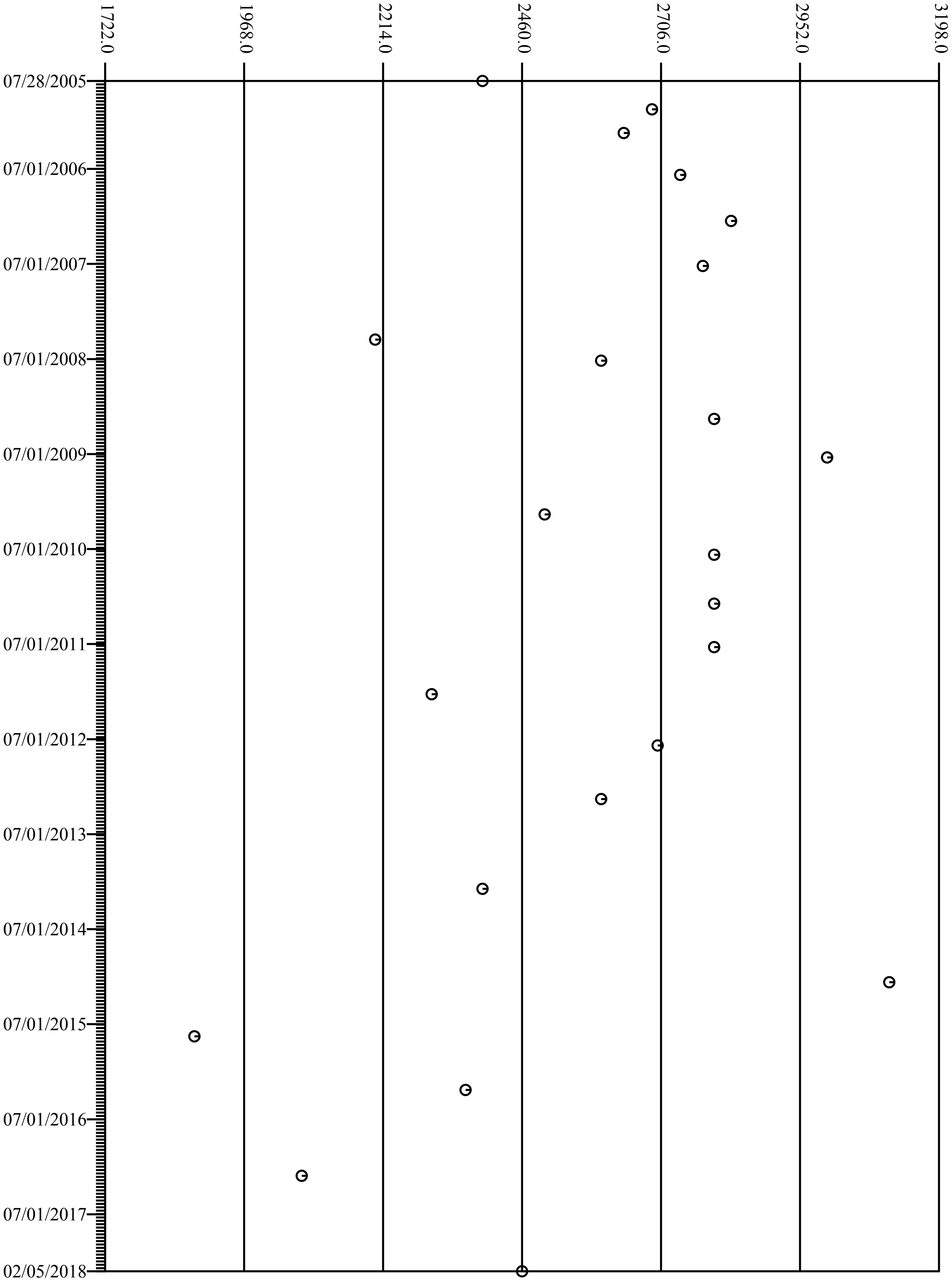
Solids, Dissolved (MG/L)



No censored data. -0.1326 Sen trend detected at 10.00% in 90.00% confidence interval -0.2382, 0.0297

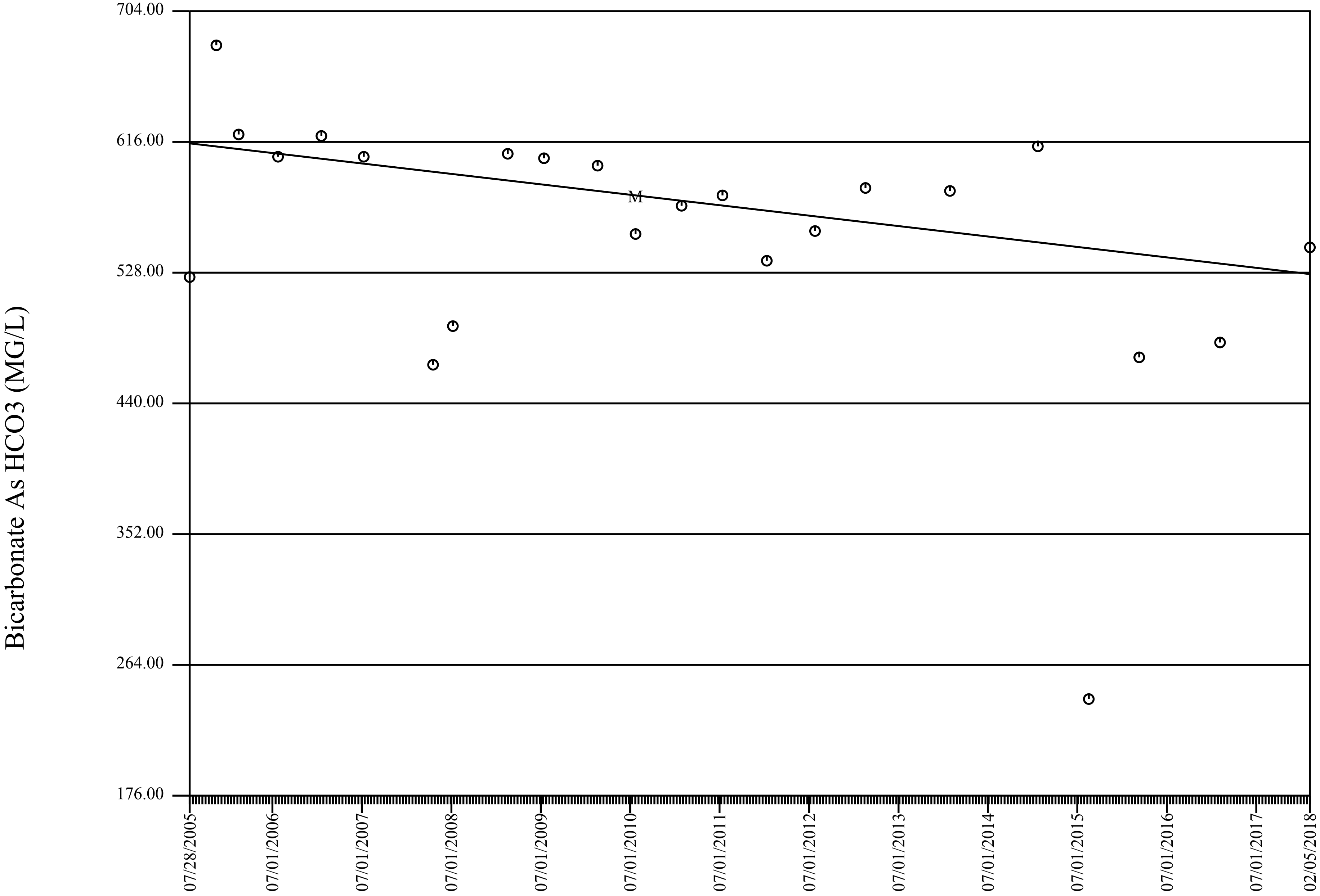
SW80R

Sulfate (MG/L)



No censored data. No trend detected at 10.00%

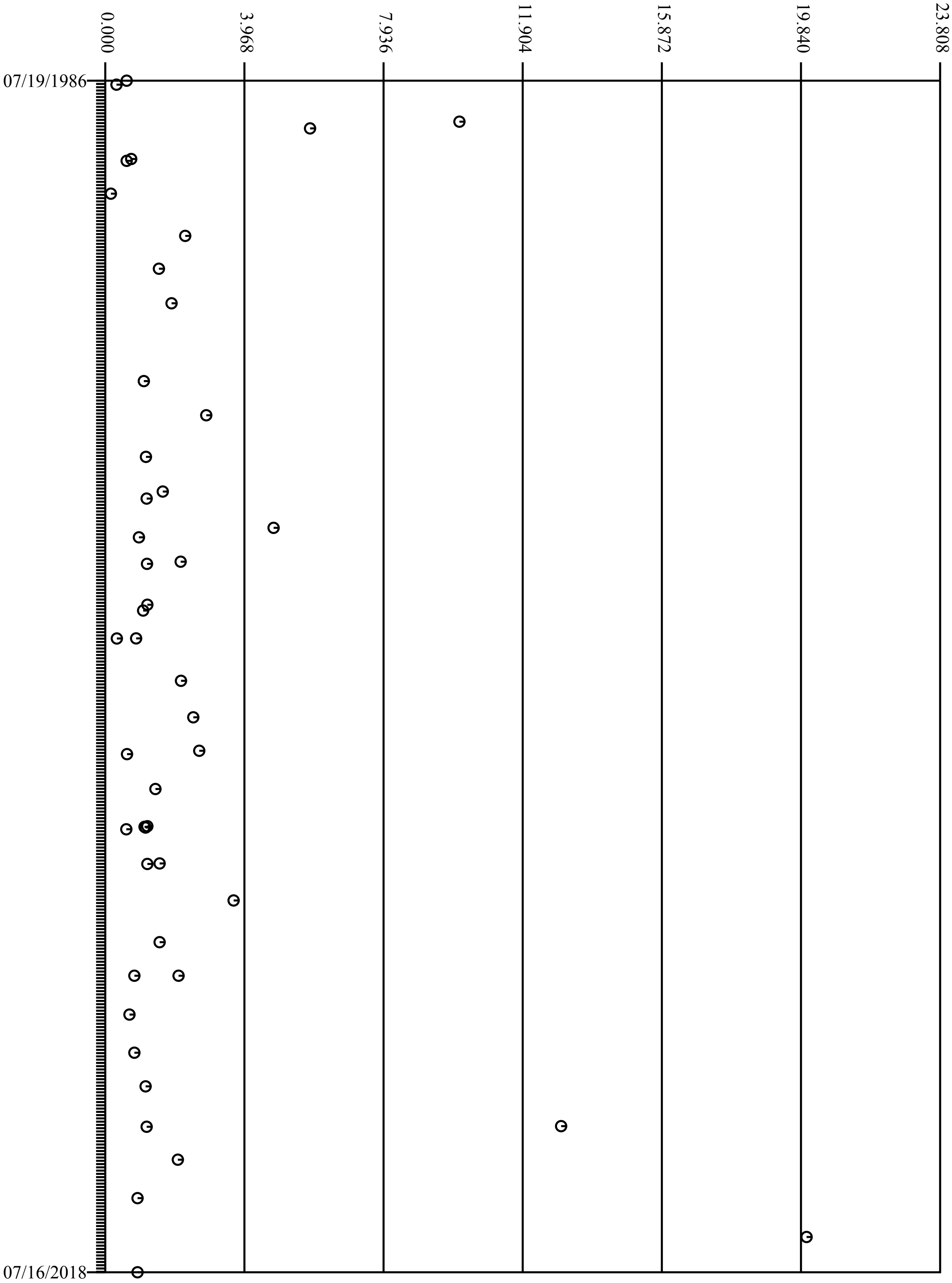
SW80R



No censored data. -0.0192 Sen trend detected at 10.00% in 90.00% confidence interval -0.0360, -0.0085

SW80R

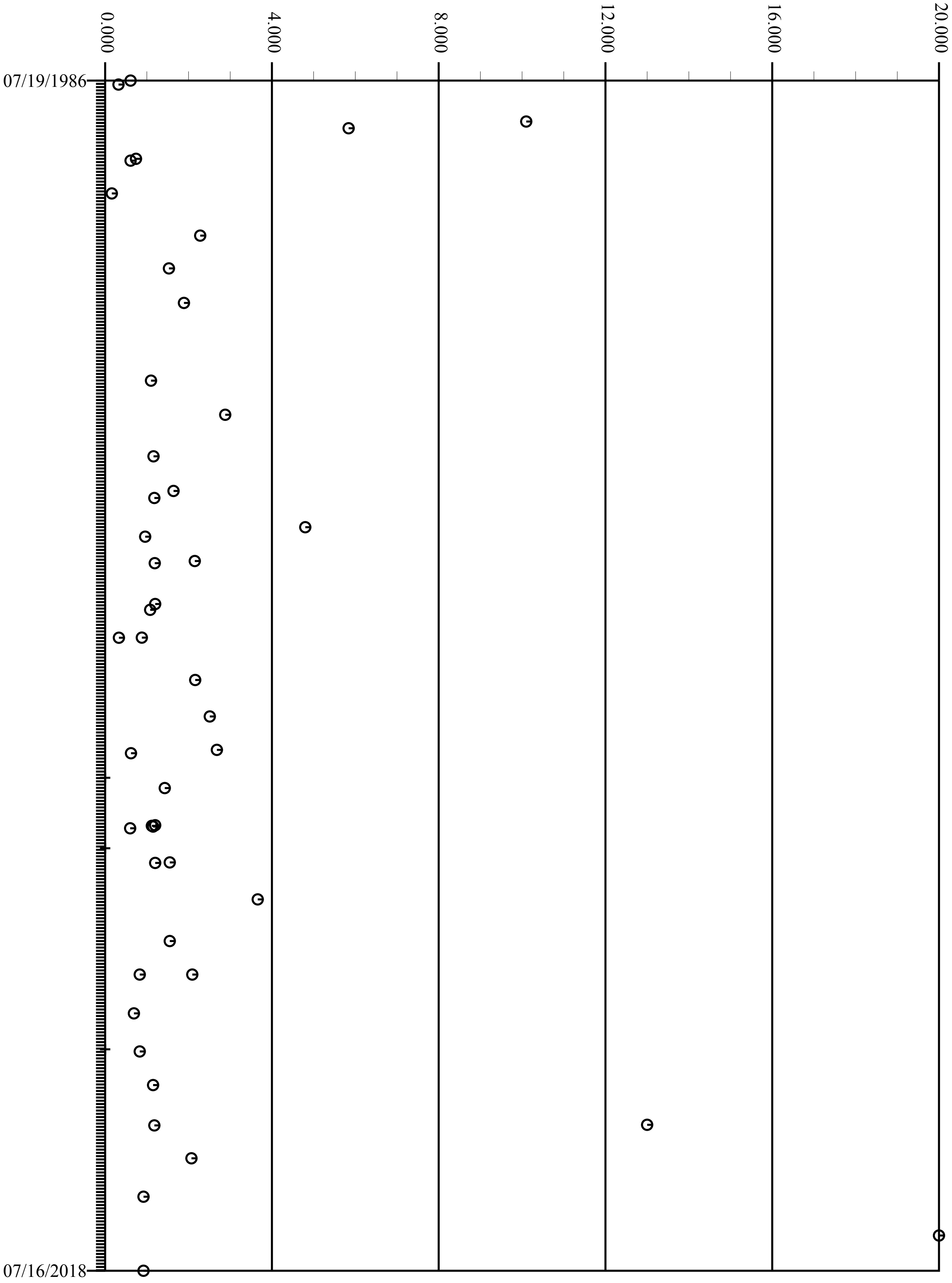
Nitrate Nitrogen_N (MG/L)



No censored data. No trend detected at 10.00%

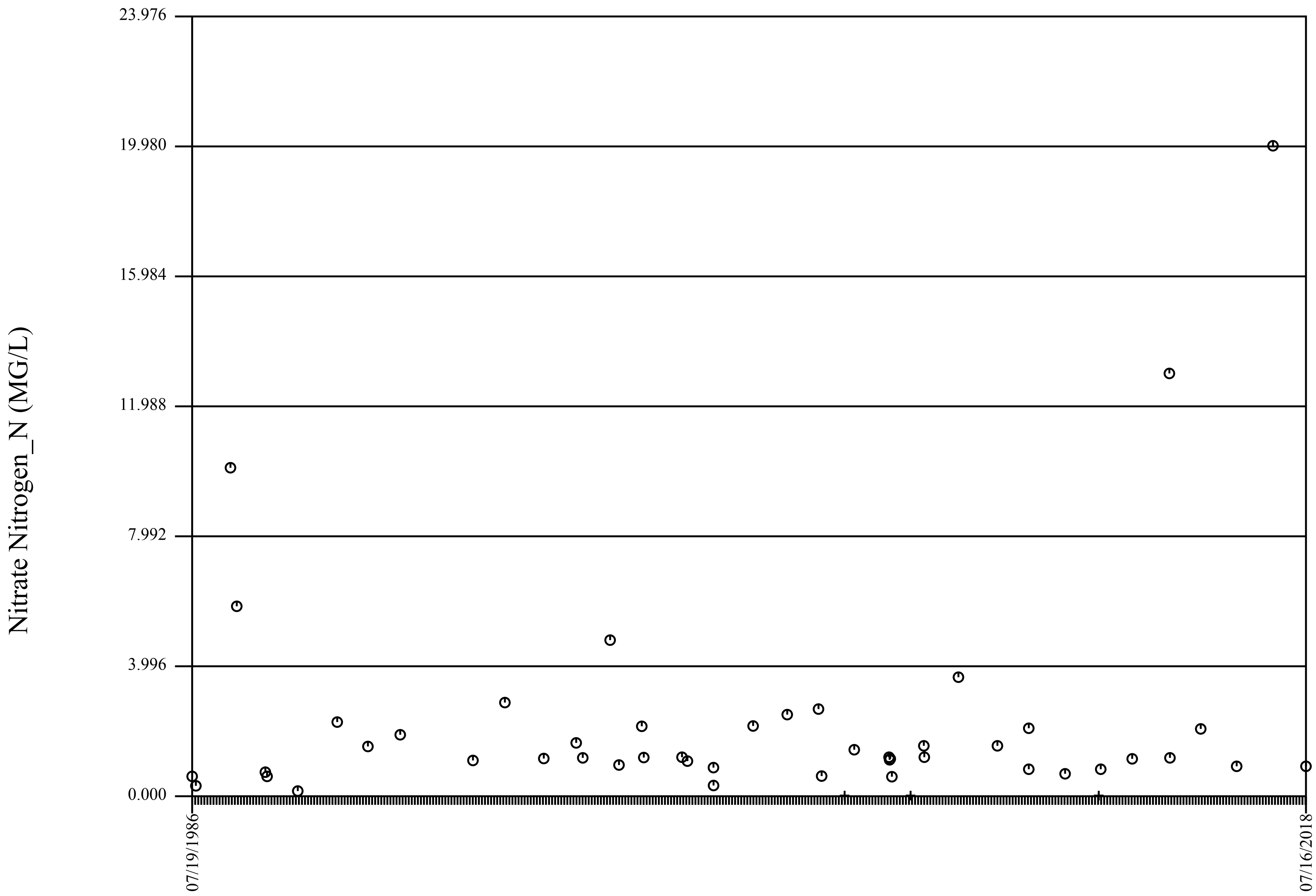
SW25

Nitrate Nitrogen_N (MG/L)



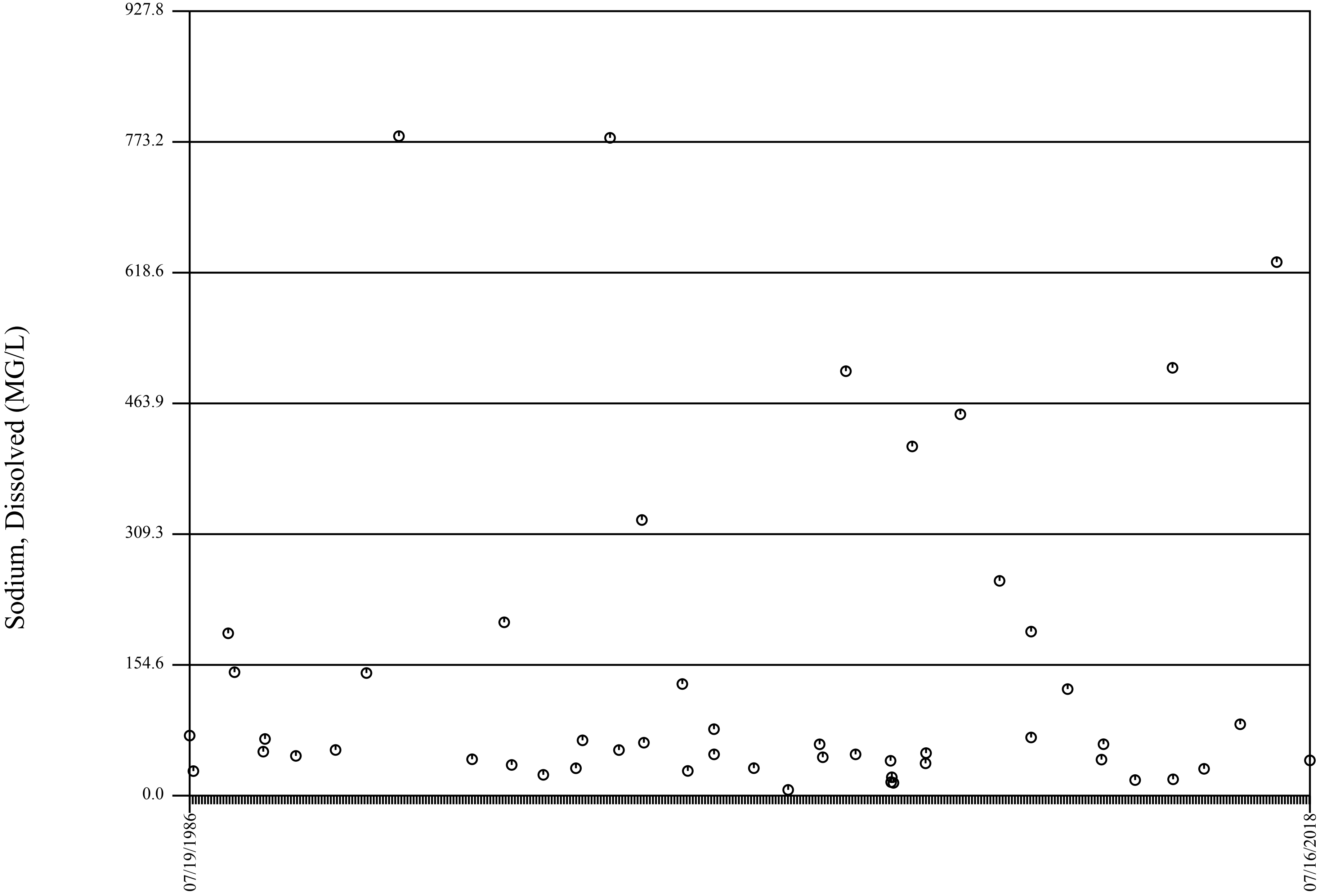
3 censored values at zero. No trend detected at 10.00%

SW25



3 censored values at limit. No trend detected at 10.00%

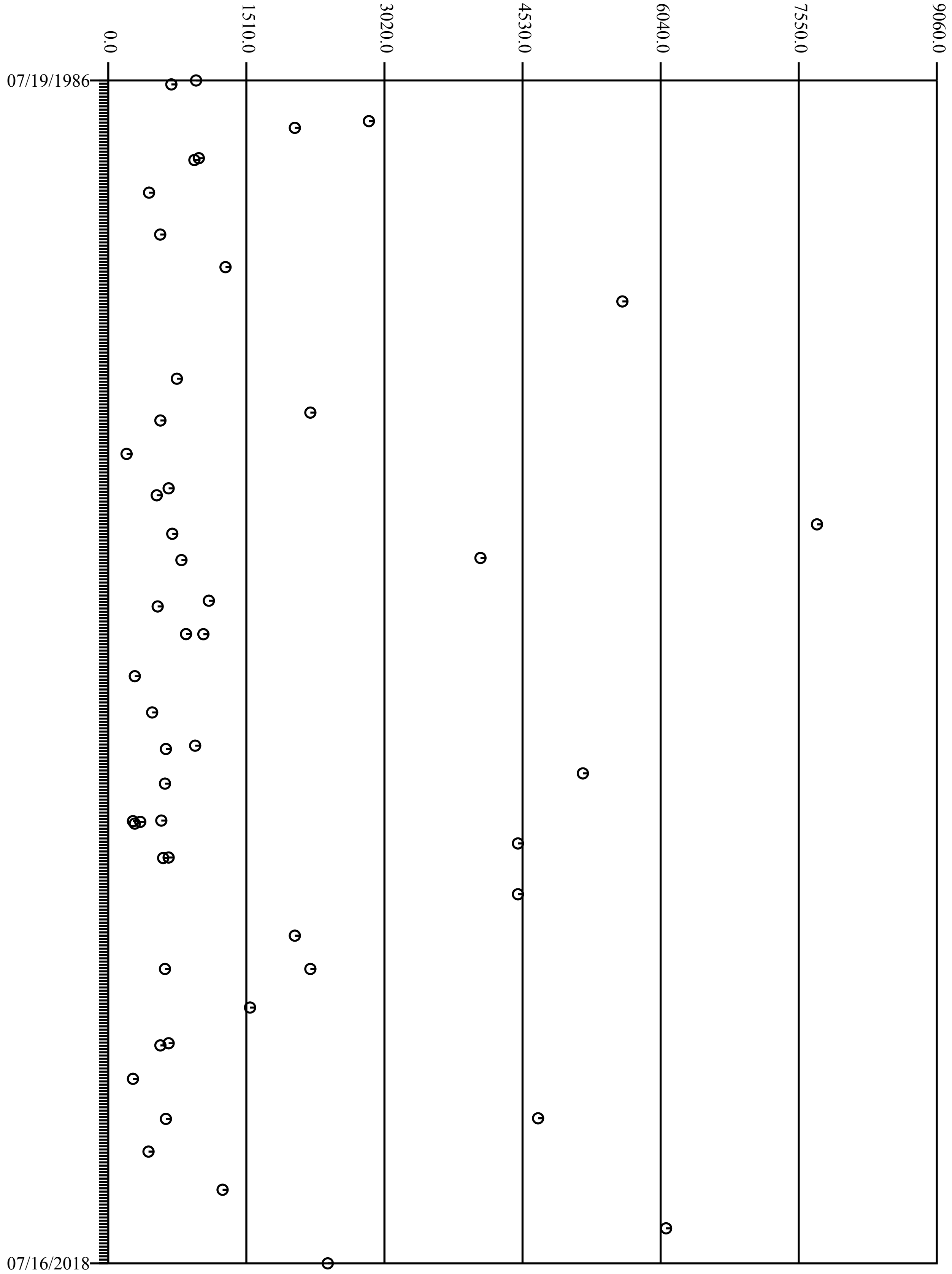
SW25



No censored data. No trend detected at 10.00%

SW25

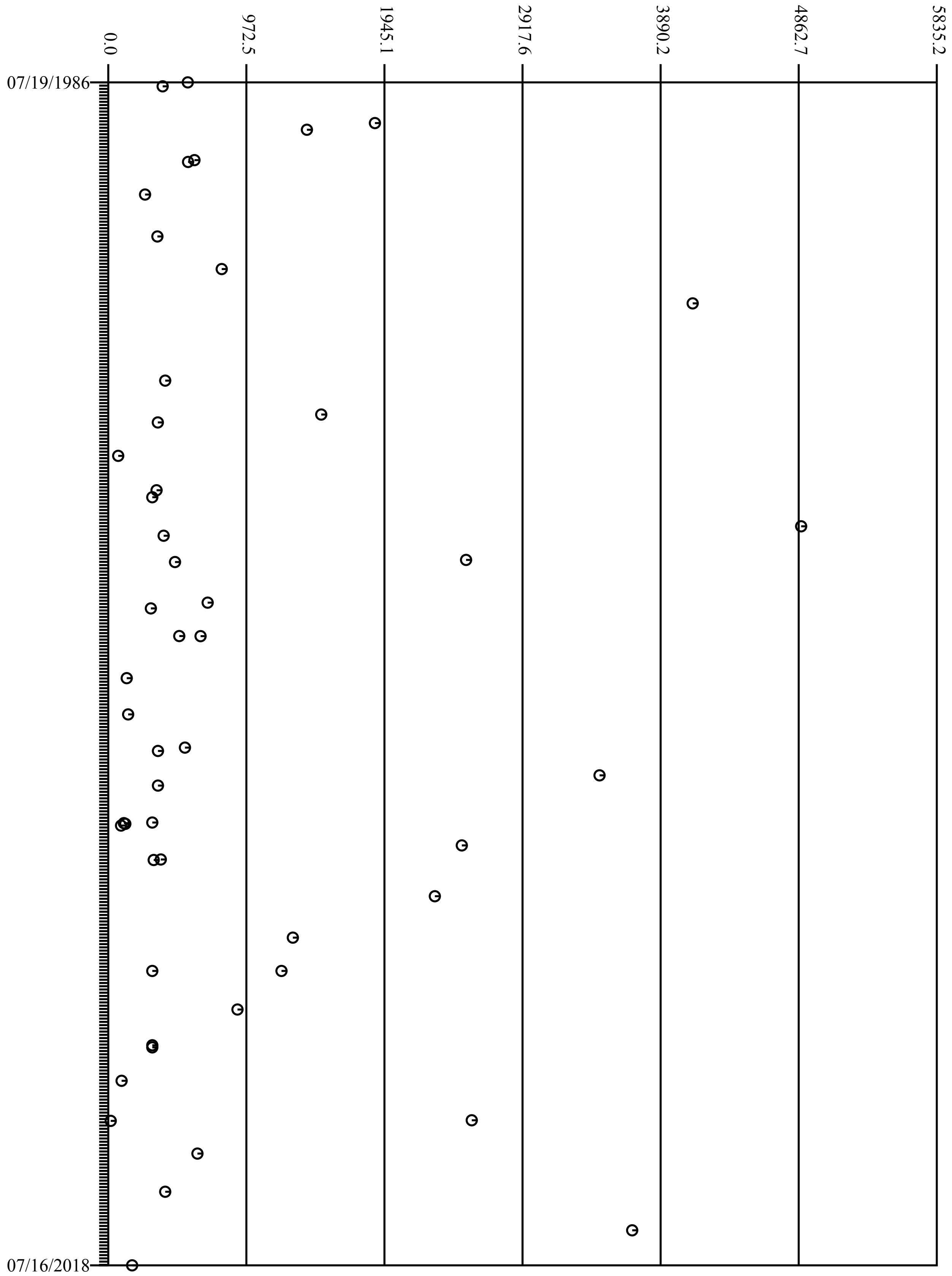
Solids, Dissolved (MG/L)



No censored data. No trend detected at 10.00%

SW25

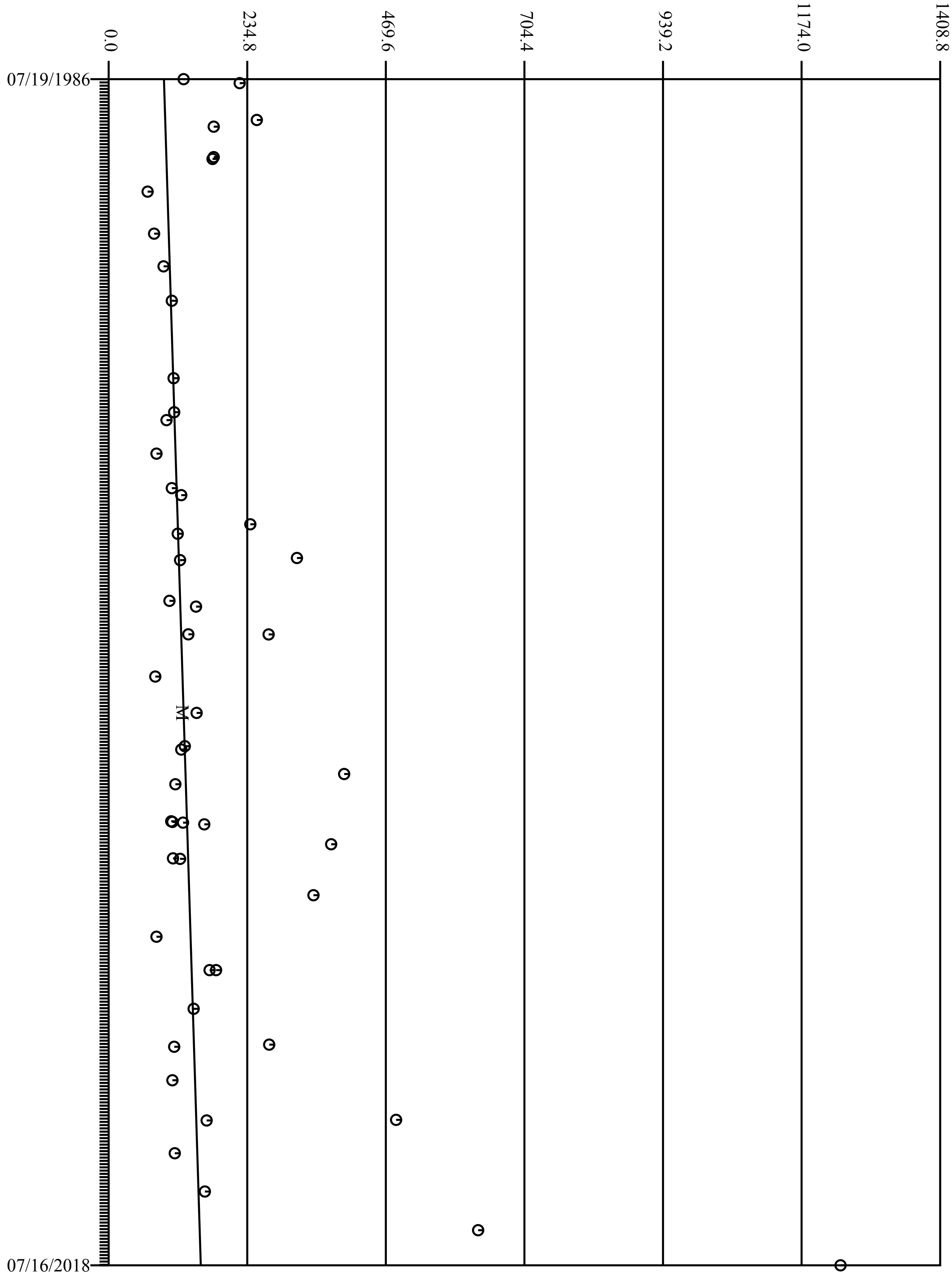
Sulfate (MG/L)



No censored data. No trend detected at 10.00%

SW25

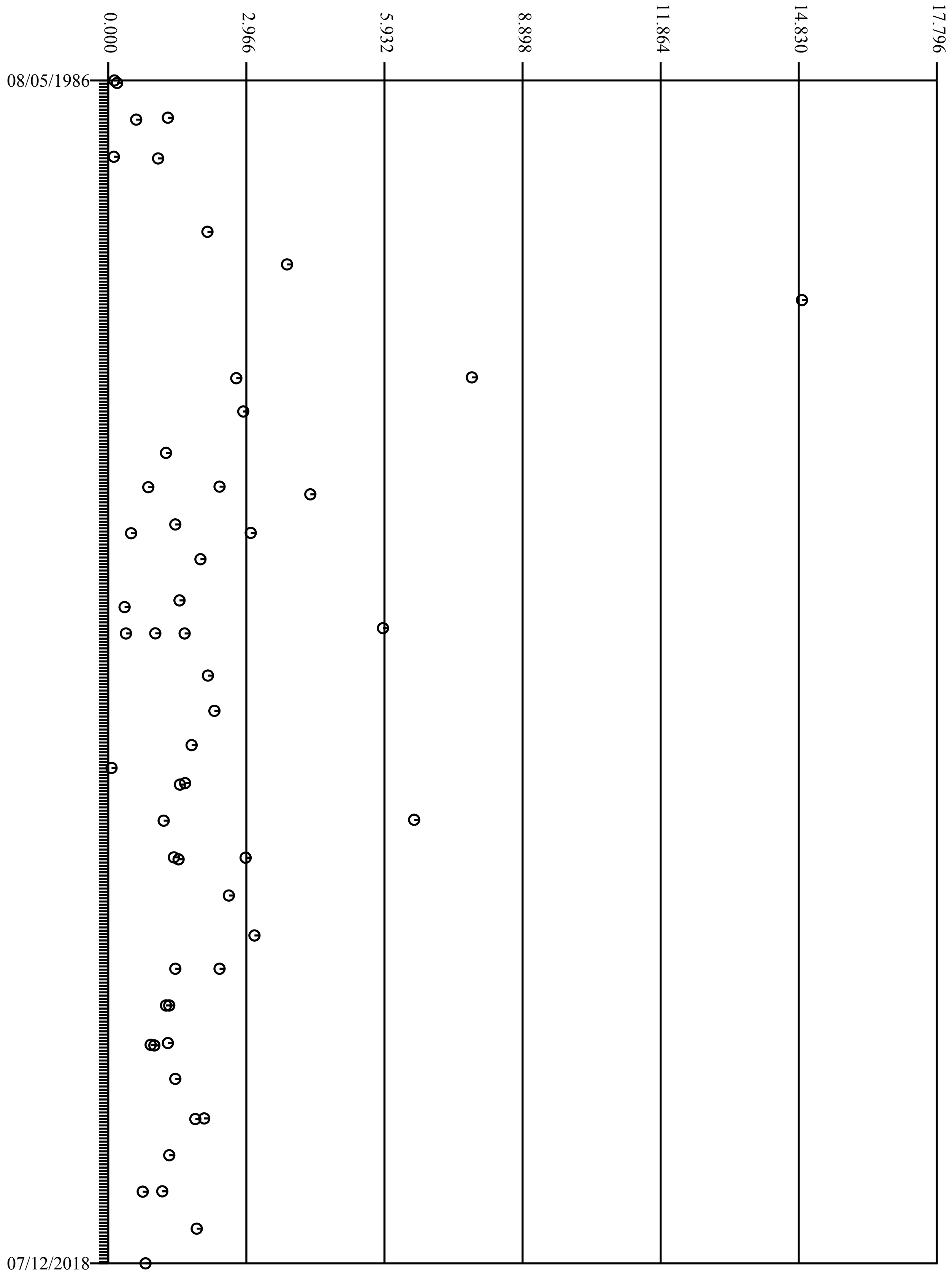
Bicarbonate As HCO3 (MG/L)



No censored data. 0.0053 Sen trend detected at 10.00% in 90.00% confidence interval 0.0008, 0.0104

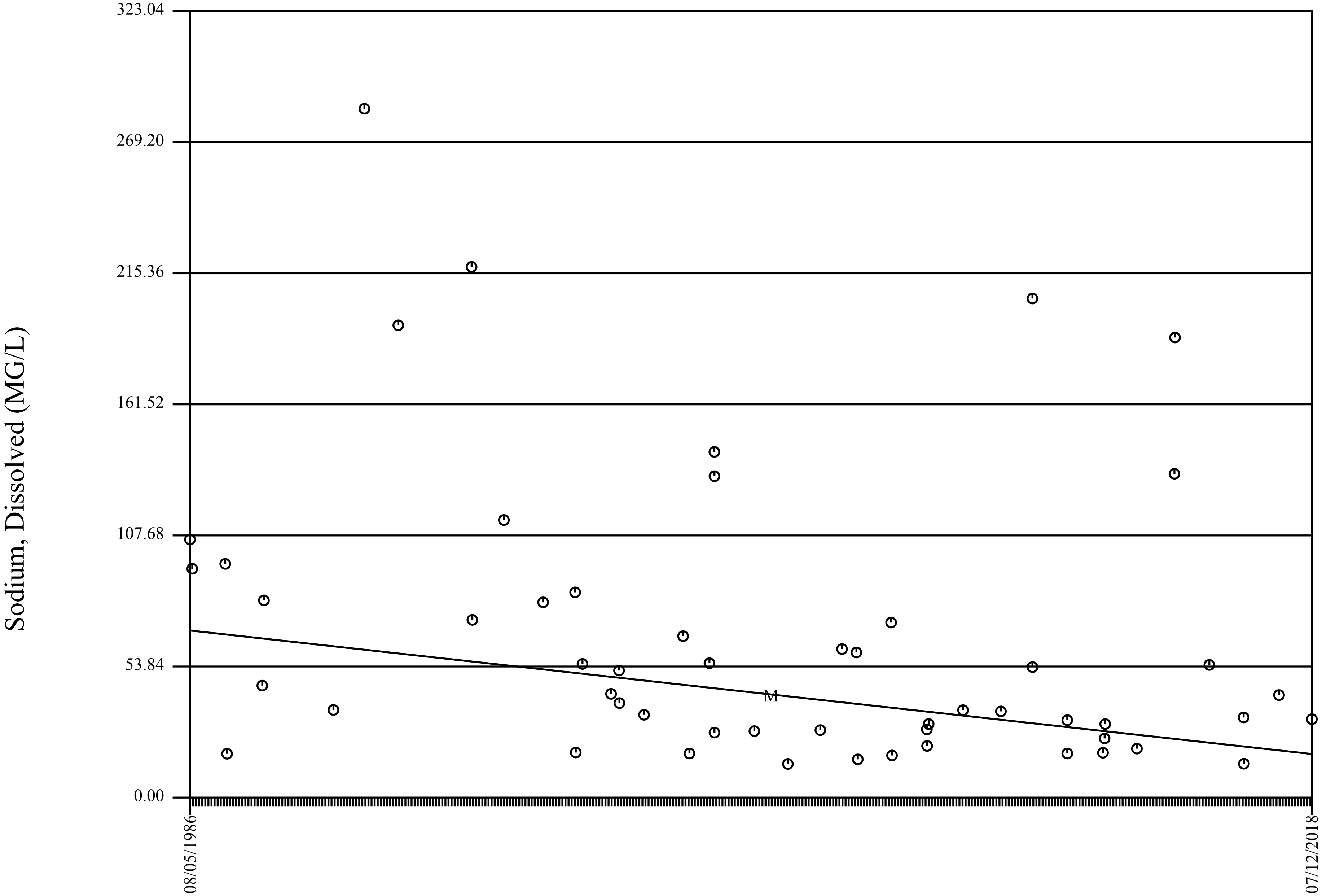
SW25

Nitrate Nitrogen_N (MG/L)



No censored data. No trend detected at 10.00%

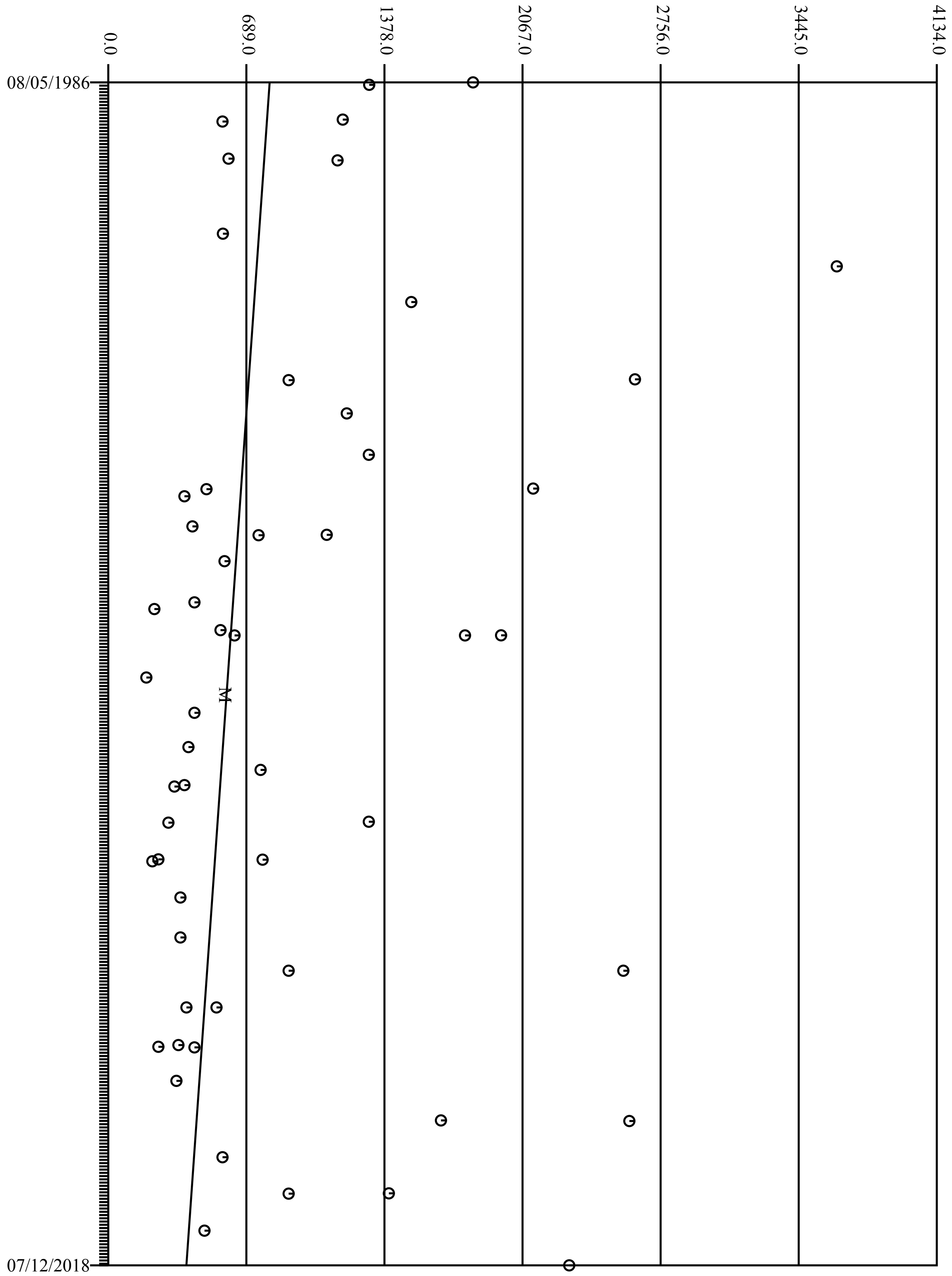
SW26



No censored data. -0.0043 Sen trend detected at 10.00% in 90.00% confidence interval -0.0071, -0.0018

SW26

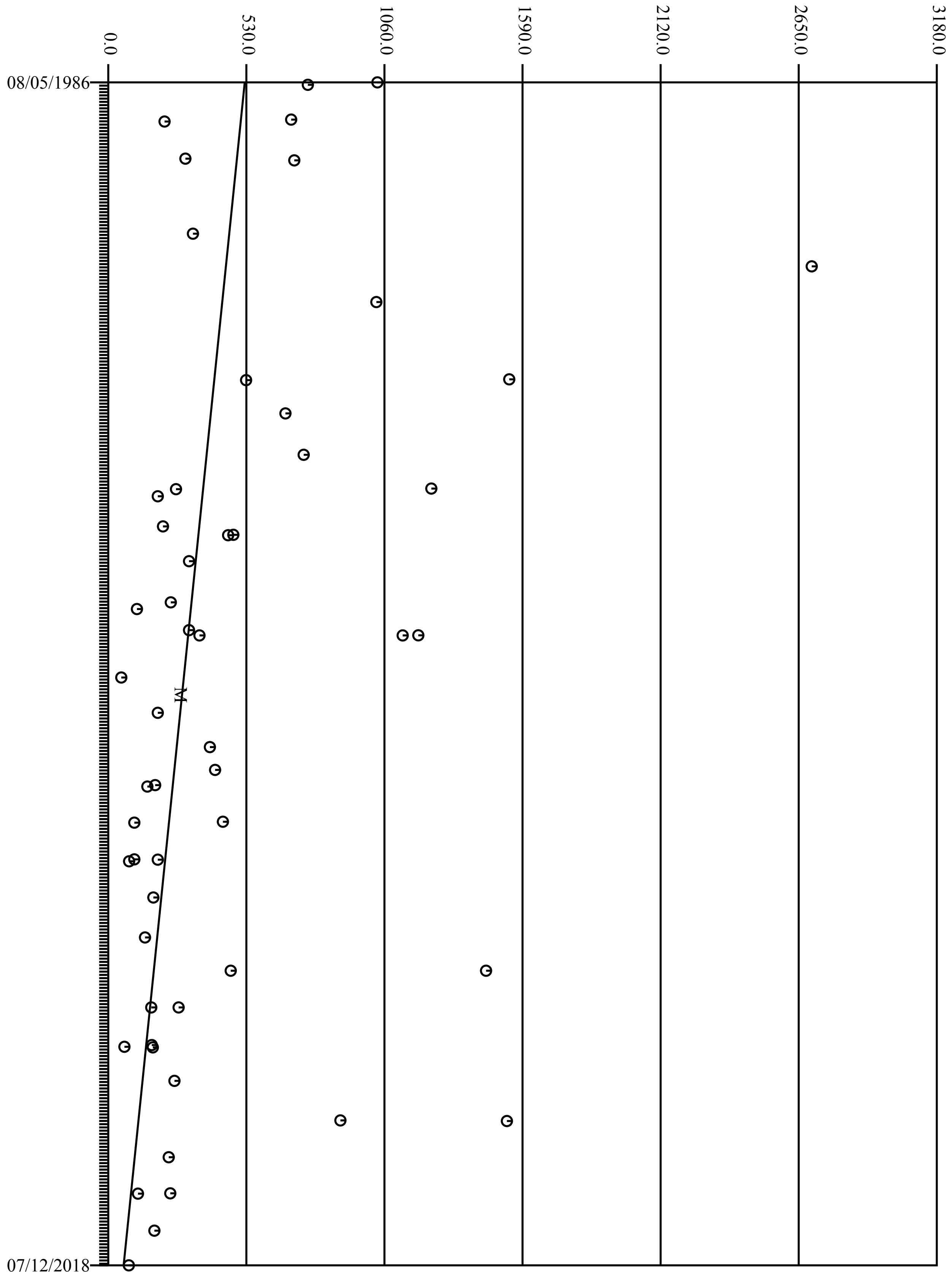
Solids, Dissolved (MG/L)



No censored data. -0.0356 Sen trend detected at 10.00% in 90.00% confidence interval -0.0795, -0.0052

SW26

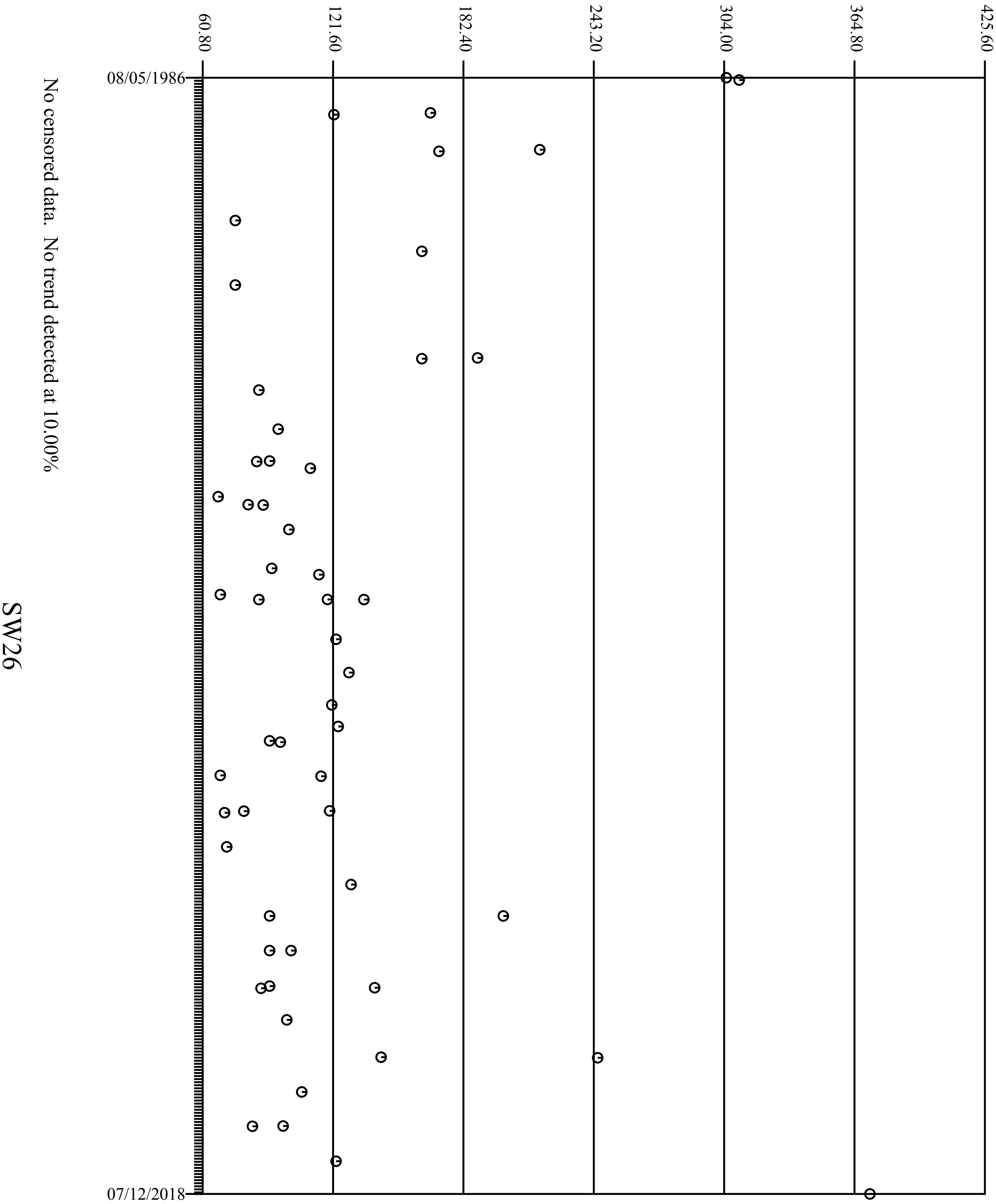
Sulfate (MG/L)



No censored data. -0.0398 Sen trend detected at 10.00% in 90.00% confidence interval -0.0625, -0.0192

SW26

Bicarbonate As HCO3 (MG/L)



TAB 3

Protection of the Hydrologic Balance

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List of Attachments
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TAB 3

Protection of the Hydrologic Balance

Ground Water Quantity

Ground Water Flow, Levels, and Gradients. Ground Water flow directions, flow gradients, and average water levels in Wepo and alluvial monitoring wells from 1980 through 1985 are presented in Chapter 15, Hydrologic Description in Volume 10 of Permit AZ-0001F and are further discussed in recent Annual Hydrology Reports (AHRs) [e.g., Peabody Western Coal Company (PWCC), 2019]. Water level contours of the Wepo and alluvial aquifers are depicted on Drawings 85610, 85611, and 85620 in Volume 23 of Permit AZ-0001F. In some locations, the Wepo water level contours on the potentiometric surface maps (Drawings 85610 and 85611; see also Maps 3.1.a and 3.1.b) "V" in an upstream direction in the vicinity of the alluvial washes, indicating the Wepo aquifer discharges to the alluvial aquifers. As such, any mining activities that intercept the Wepo aquifer can potentially affect the downgradient alluvial aquifers. The following sub-sections focus on changes in ground water flow, levels and gradients in the Wepo aquifer below and proximate to each of the four reclaimed coal resource areas (CRAs) (J-1, N-6, J-16 and N-14) that are subject to this Termination of Jurisdiction (TOJ) application. Changes in water levels monitored in alluvial wells proximate to the J-1/N-6 and J-16 CRAs are also provided. Because mining of the N-6 CRA featured pits that extended to the south into the J-1 CRA as mining progressed from east to west, analysis of hydrologic impacts including ground water flow, levels and gradients are combined under the designation J-1/N-6 for both areas throughout the remainder of this document.

The Wepo aquifer was affected between 1972 and 2008 in the J-1/N-6 CRAs, between 1982 and 1993 in N-14, and between 1982 and 1999 in J-16. Water level changes in the wells associated with these locations can be found in Table 3.1a, a subset of Tables 2 and 3 found in the 2018 Annual Hydrology Report (AHR) for the Kayenta Mine (PWCC, 2019). The AHR provides a comprehensive look at the current and past hydrology of the area along with trends seen in the chemistry and water levels of currently monitored wells. Water level hydrographs for monitoring wells associated with each of the three TOJ parcels (J-1 is combined with N-6) are provided in Attachment 3-1a for alluvial wells and Attachment 3-1b for Wepo wells.

J-1/N-6 TOJ Parcel. Mining within the J-1/N-6 reclaimed TOJ parcel commenced in 1972 as initial box cuts were developed in the far western portion of J-1, and in 1976 in the eastern portion of J-1. After the initial box cuts were completed, mining progressed generally northward into the N-6 parcel to accommodate the development of longer pits, and mining activities within the J-1 portion of the TOJ parcel ended in 1983. The most recent mining within the N-6 portion of the TOJ parcel, which is comprised of two areas separated by gradual shortening of the final pit from about 2001 through 2008, was completed in the far western and northern portions of N-6 in about 2000. Theoretical projections of potential ground water inflow to the J-1/N-6 mining area are provided in Chapter 18, Probable Hydrologic Consequences (PHC) in the AZ-0001F permit. Some ground water was intercepted in the southern portion of the parcel during the late 1970’s and mid-1980’s in the vicinity of J-1 and far southern pits of N-6 based on observations made by mine personnel, but no physical measurements of ground water inflows in these areas were collected. No ground water inflows were observed as the mining pits progressed generally to the north and west from the mid-1980’s through final closure (spoil backfilling) completed in 2012. Four Wepo monitoring wells were constructed in 1980 proximate to the J-1/N-6 TOJ parcels, including well 43 to the southwest, well 40 due west, well 44 due south, and well 53 to the north (refer to Drawing No. 93500, Current Environmental Monitoring Sites, Drawing No. 85300, Historic Environmental Monitoring Site Map, Permit AZ0001F and Maps 3.1.a and 3.1.b, attached). Wepo well 43 was replaced in 1997 with well 43R due to expansion of the adjacent gravel pit located to the west. Monitoring of water levels and water quality in these wells (excepting 43R) began in 1980. Comparisons of Wepo aquifer water level contours constructed using early data collected at the four wells (Drawing 85610) with contours constructed using data collected after 1985 (Drawing 85611) indicate no changes to the Wepo aquifer gradients occurred over time in the middle and southern portion of the J-1/N-6 TOJ parcels (0.015 to 0.018 ft/ft). In the northern section, the premining gradient was approximately 0.025 ft/ft, and lowered slightly to 0.021 ft/ft as mining progressed to the west. Overall, flow in the Wepo aquifer below the J-1/N-6 parcel is predominately to the southwest and little change in the general pattern of flow direction has occurred for several decades.

In 2010, PWCC drilled two monitoring wells, designated SPL601 and SPL602 in regraded spoil (see Drawing 93500). These two wells are located within the J-1/N-6 TOJ parcel and were completed at depths of 41 feet (SPL601) and 145 feet (SPL602). The completion depth of each spoil well represents the entire thickness of the spoils present in each area. To date, both of these wells have been dry providing evidence re-saturation of spoils has not yet occurred.

Water level data collected in wells 40, 53, 43, 43R and 44 suggest localized responses to mining activities within the J1/N6 TOJ parcel have occurred during mining (see Attachment 3-1b). Water levels in up-gradient well 53 showed a marked decline of more than 24 feet beginning in 1989 through 2002, likely related to the progression of mining in N-6 to the south. However, subsequent water levels remained relatively stable through 2012 followed by approximately 6 feet of rise through 2018 (PWCC, 2019). Well 40 water levels exhibit a 10-foot decline from 1995 through 2006, followed by a rise of some 6 feet through 2018. Due to its location to the west of the N-6 pit, the decline may have resulted from mining progression in the N-6 pit to the east. Recovery of water levels is evident at well 40 from 2006 through 2018 as the coal reserves were mined out and final backfilling was completed in 2012. Well 43 water levels deepened more than 5 feet from 1989 through 1992 principally due to expansion of the adjacent gravel pit, and as mining activities progressed in the upgradient J-1/N-6 pit. Replacement well 43R also showed a deepening water level trend from 1999 through 2004, but levels shallowed some 14 feet through 2016, followed by a 4-foot decline as of 2018 (PWCC, 2019). PWCC believes water level trends in Wells 43 and 43R have been largely influenced by extraction activities and expansion of the adjacent gravel pit as opposed to mining activities that occurred over decades in the upgradient J-1/N-6 mining area. Well 44, located south of the J-1/N-6 TOJ parcel exhibits a long-term shallowing trend in water levels, with a gradual rise of more than 20 feet since 1990 (PWCC, 2019). Recent water levels in Wells 53 and 44 also show gradual rises in recent water levels and may indicate recovery of Wepo Formation water levels is occurring in these areas. Table 3.1a provides historic ranges of water levels collected at wells 40, 43R, 44 and 53 along with maximum predicted drawdown for each well as provided in Table 8, Chapter 18 (PHC) of the AZ-0001F Permit Application Package (PAP). Historic water level ranges and the most recent measurement (2018) in all four wells are appreciably below the maximum predicted drawdown. Overall, minimal changes to the potentiometric surface and flow directions indicate negligible impacts have occurred to the quantity of groundwater within the Wepo aquifer in the vicinity of the J-1/N-6 TOJ parcel.

Several alluvial monitoring wells have been installed and monitored in alluvial deposits in Coal Mine Wash that flows along the western edge of the J-1/N-6 parcel. Alluvial wells 17 (installed 1980) and 200 (installed 1991) are located in upper Coal Mine Wash approximately 1 mile upstream and upgradient of the J-1/N-6 parcel (see Drawing 93500). Water levels in both wells show similar seasonal variability driven by the magnitude and duration of runoff events with periodic fluctuations of 1 to 2 feet (see Attachment 3-1a). During periods of below average precipitation, water levels tend to gradually decline. Higher and more frequent runoff events during wetter seasons can result in rising levels in both wells in excess of 2 feet. Figure 2, shown in the 2018 AHR (PWCC 2019) provides long term rainfall measured at the leasehold and at Betatakin National Monument for comparison purposes. Alluvial well 80 was installed in Coal Mine Wash near the northwest edge of the parcel in 1980 and was replaced by well 80R in 1998 due to possible over-drilling of the original well into the Wepo Formation. Water levels in both wells also show some seasonality due to lack of runoff or increased runoff depending on upstream runoff contributions. Water levels from 2004 through 2018 in well 80R show a steady decline of approximately 2 feet. Alluvial well 193 was installed in 1980 about 1 mile downstream of well 80, and water levels in this well also show seasonality with a general decline of about 2 feet after 2003. Thereafter, similar seasonal fluctuations of less than 1 foot are evident in part due to changes in monitoring frequency from monthly (1980 – 1990) to semi-annually (2002 – present) and also the influence of encroachment of thick tamarisk nearby. Alluvial well 83 was installed approximately 1 mile downstream of well 193 along Coal Mine Wash in 1992. Water levels in well 83 have consistently exhibited seasonal fluctuation of 1 to 2 feet through its monitoring history, with a general increasing trend of about 3 feet after 2003. Mining in the N-6 pit approached Coal Mine Wash until final reclamation (backfilling and grading) of the N-6 Pit was completed in 2012. Periodic declines in water levels at wells 80R down to well 83 just upstream of Navajo Route 41 (NR 41) likely resulted from encroachment of thick tamarisk stands along Coal Mine Wash, and not mining and final reclamation of the adjacent N-6 pit. Alluvial well 197 was installed in 1992 on Coal Mine Wash more than 1 mile downstream of the NR 41 crossing just upstream of its confluence with Yellow Water Canyon Wash (see Drawing 93500). Water levels collected at well 197 exhibited markedly different responses compared to alluvial wells located further upstream. A steady decline of more than 20 feet occurred from 1993 through 2003, followed by shallowing of some 10 feet into 2008. Another decline of 6 feet followed through 2001, and levels have stabilized relatively from 2013 through 2018. Due to the aggradation of sediment deposits along Coal Mine Wash upstream of NR41, baseflow below the crossing now extends downstream to well 197. Encroachment of tamarisk along Coal Mine Wash in the vicinity of well 197 has been minimal compared to the entire reach upstream of NR 41. The culverts at the NR 41 crossing have served to restrict large runoff events generated upstream along Coal Mine Wash over time, allowing tamarisk to thrive and encroach on the terraces along the stream channel. Table 3.1b provides historic ranges of water levels collected at wells 17, 200, 80R, 83, 193 and 197 along with maximum predicted drawdown for each well as provided in Table 8, Chapter 18 (PHC) of the AZ-0001F PAP. Historic water level ranges and the most recent measurement (2018) in all six wells are well below the maximum predicted drawdown.

J-16 TOJ Parcel. The majority of mining within the J-16 reclaimed TOJ parcel occurred between 1982 and 1995. The final cut of mining in this pit occurred in 1999 following a three-year period of idled activity in the pit due to periodic outbreaks of spoil fires in limited areas along the exposed highwall and spoil ridges near the idled pit. Backfilling and grading in J-16 was completed in about 2000. Wepo monitoring well 62R is situated approximately 0.25 miles upgradient of the J-16 TOJ parcel. Well 62 was constructed in 1980 prior to the onset of mining in J-16 and was monitored through 1998 when it was abandoned ahead of final highwall slope reduction and replaced by well 62R (see Drawings 93500 and 85600, respectively). Ground water flow in the J-16 TOJ parcel is towards the southwest (towards Reed Valley Wash) and northwest (towards Moenkopi Wash) along a ridge of relatively higher potentiometric surface that runs through the middle of the J-16 mining area (see Drawings 85610 and 85611). Comparisons of Wepo aquifer water level contours constructed using early data collected at Wepo wells in the eastern portion of the leasehold (Drawing 85610) and contours constructed using data collected after 1985 through 2003 (Drawing 85611) indicate minimal changes to the Wepo aquifer gradients occurred since monitoring began. The Wepo ground water gradient in the direction of Reed Valley decreased slightly by 0.001 ft/ft, and no measurable change in gradient occurred towards the northwest. Groundwater was encountered seeping from the pit face during the last several years of mining in J-16 as mining progressed to the east. However, no measurements of inflows were made. Based on Wepo water level contours (Drawing 85610) and groundwater seepage along the highwall during the latter years of mining, PWCC installed spoil well SPL161 in 1995, and wells SPL162 and SPL163 in 2010 to determine whether re-saturation of graded spoils would occur with time (see Drawing 93500). Through 2018, only well SPL162 featured measurable water but at minimal amounts (< 2 feet above well TD). After more than 2 decades, negligible changes in the flow direction and ground water gradient in the Wepo aquifer have occurred below and downgradient from the J-16 TOJ parcel.

A review of water levels collected in the two Wepo monitoring wells (62 and 62R) indicates dewatering of the Wepo aquifer downgradient of well 62 occurred between about 1985 through 1995 as mining progressed to the east evidenced by an overall drop in water level of more than 100 feet followed by a rise of some 60 feet into 1997. Water levels collected from replacement well 62R from 1996 through 2008 show an overall rise of some 15 feet, followed by relatively stable water levels through 2018. Water levels collected at well 62 and 62R during mining and following final pit reclamation (backfilling and grading) indicate water levels in the Wepo aquifer beneath the J-16 parcel have re-established a new equilibrium. Table 3.1a provides historic ranges of water levels collected at wells 62 and 62R along with maximum predicted drawdown for each well as provided in Table 8, Chapter 18 (PHC) of the AZ-0001F PAP. Recent water level measurements after 1995 and the most recent measurement (2018) in well 62R are well below the maximum predicted drawdown. Combined with negligible changes to the potentiometric surface and flow directions, minimal changes have occurred to the quantity of Wepo aquifer in the vicinity of the J-16 TOJ parcel.

Several alluvial monitoring wells have been installed and monitored in alluvial deposits along Moenkopi Wash that courses northwest of the J-16 mining area less than 0.5 miles from the most proximate extent of mining. Alluvial Well 87 (installed 1980) is located approximately 2.5 miles upstream of the J-16 parcel well upstream of mining activities. Water levels in well 87 show seasonal variability driven by the magnitude and duration of runoff events with periodic fluctuations of up to 5 feet during years with relatively high annual precipitation (see Attachment 3-1a and Figure 2 shown in the 2018 AHR [PWCC 2019]). During periods of below average precipitation, water levels tend to gradually decline. Comparison of the long-term water level record at well 87 with Figure 2 from the 2018 AHR (PWCC 2019) provides general confirmation of the seasonal variability, although rainfall varies considerably within and adjacent to the PWCC leasehold. Alluvial well 23 (installed 1980) is located about 1.3 miles downstream of well 87, and its record through 2001 exhibits seasonal water fluctuations ranging from several tenths of a foot upward to 2 feet. However, water levels in well 23 were consistently near the total depth of the well indicating minimal alluvial groundwater saturation along that reach. Accordingly, an additional well was installed near well 23 in 1990 (designated well 23R) in an attempt to confirm minimal saturation. Water levels at well 23R have been dry through 2018 except for several inches measured in July 1993 following several years of particularly high precipitation (see 2018 AHR Figure 2 [PWCC 2019]). Wells 88 and 89 were installed in 1980 along Moenkopi Wash approximately 0.5 miles from the western edge of the J-16 parcel (see Drawing 85600). Both wells exhibited similar water level patterns of seasonal variability with annual fluctuations of about 2 feet. Although a slight deepening trend can be seen in the water level record for well 88 from 1991 through 1996, mining had progressed appreciably to the east away from Moenkopi Wash during that period. Early water levels collected at well 89 located near well 88 mimicked the overall pattern seen at well 88 through 1992. Both wells 88 and 89 were abandoned because of over-drilling into the Wepo Formation. Water levels in well 89R (installed 1988 near well 89) mimicked the patterns seen in wells 88 and 89 through their respective monitoring record and have since risen some 4 feet through 2018.

Well 27 (installed in 1980) was located along Reed Valley Wash that courses westerly near the southern edge of J-16. Well 27R was installed in 1990 to serve as a replacement for well 27 and was monitored for water levels up through 2002 when the Office of Surface Mining Reclamation and Enforcement (OSM) approved temporary cessation of monitoring (idled). Early water levels at well 27 show small seasonal fluctuations through 1984 (about 1 foot), followed by several rises of more than 4 feet and a general decline of more than 6 feet through 1992 when monitoring was discontinued. Water levels at well 27R mimic well 27 up through 1992. Water levels at 27R show a five-foot rise during 1993 when regional precipitation was well above average. Thereafter, water levels at 27R show a general decline more than 7 feet along with small seasonal fluctuations through 2002. The majority of mining in J-16 occurred from 1982 through 1995. Water levels in both 27 and 27R showed an overall rise in levels through 1988. Based on the timing of mining in J-16, the overall decline in water levels at 27R through 2002 is likely a result of lower precipitation, and to a lesser extent, construction of additional sediment control ponds upstream in Reed Valley Wash associated with the J-28 Facilities and J-21 mine areas. Additional ponds upstream have temporarily reduced the drainage area contributing to alluvial deposits in lower Reed Valley Wash.

Table 3.1b provides historic ranges of water levels collected at wells 87, 23, 23R, 88, 89, 89R, 27 and 27R along with maximum predicted drawdown for each well (except 27R due to its idled status after 2002) as provided in Table 8, Chapter 18 (PHC) of the AZ-0001F PAP. Historic water level ranges and the most recent measurement (2018) in all alluvial wells currently monitored along Moenkopi Wash are well below the maximum predicted drawdown. The water levels measured at wells 88, 89 and 89R, all of which are located in the alluvium along Moenkopi Wash near the western edge of J-16, indicate impacts from mining in J-16 on groundwater quantity in the alluvium along Moenkopi Wash were minimal.

N-14 TOJ Parcel. Mining within the N-14 reclaimed TOJ parcel was conducted in two areas separated by a strip of land that was not mined due to poor coal quality. Mining commenced in 1982 in the western area along its southern edge and generally progressed north after initial box cuts were completed and longer pits were developed. Mining in the western area ended in 1993. Mining in the eastern area began in 1984 on its western edge, commenced along its eastern edge in 1989 and progressed toward the final cut until about 1992. Final reclamation activities (backfilling and grading) in N-14 were completed as of about 1995. Two natural springs were found upgradient of the N-14 mining area prior to mining (e.g., NSPG97 & NSPG111, see Drawings 85300 and 93500) indicating the presence of near-surface ground water. Spring NSPG97, located in the upper northwestern corner of N-14 (see Drawing 85300) was removed by mining in 1984. Persistent water observed in proposed permanent impoundments N14-D, N14-F and N14-G suggests shallow groundwater inflow also contributes to surface water runoff to these ponds. However, no significant amounts of ground water were encountered as mining progressed throughout N-14 with the exception of occasional seepage from the highwall in the eastern portion of the N-14 pits. Two Wepo monitoring wells were constructed in 1980 proximate to the N-14 TOJ parcel, wells 49 and 54. Well 54 is located approximately 0.4 miles south of the western edge of the N-14 parcel, and well 49 is located about 0.2 miles south of the eastern portion of N-14 (refer to Drawing No. 93500 and Maps 3.1.a and 3.1.b, attached). Both wells are located downgradient of the N-14 parcel, and no upgradient wells exist to the north. Monitoring of water levels and water quality in these wells began in 1980.

Comparisons of Wepo aquifer water level contours constructed in the vicinity of N-14 using early Wepo water level data and data collected after 1985 indicates minimal changes in gradients have occurred from 1980 through 2003 (0.002 ft/ft decrease along the west of N-14; 0.001 ft/ft increase along the east of N-14). Flow directions have also maintained a southern direction across N-14 during this same period.

A review of water levels collected in the two Wepo monitoring wells in the vicinity of the N-14 TOJ parcel indicates negligible impacts have occurred as a result of mining. Water levels in well 49 showed minor declines of about 2 feet beginning in 1983 through 1985, followed by an overall rise in water level of almost 10 feet through 2003. Recent water levels through 2018 have fluctuated less than 1 foot and have been near ground surface. Water levels at well 54 declined about 6 feet through 1982 that may have resulted from proximate box cuts, followed by a rise of 5 to 6 feet into 1984 as pits were lengthened and mining progressed northward away from the well. Since 1984, water levels in well 54 have been relatively stable with seasonal fluctuations no greater than 2 feet. Table 3.1a provides historic ranges of water levels collected at wells 49 and 54 along with maximum predicted drawdown for each well as provided in Table 8, Chapter 18 (PHC) of the AZ-0001F PAP. Water level measurements in both wells after 1984 are well below the maximum predicted drawdown. Combined with minimal changes to the potentiometric surface and flow directions, minimal changes have occurred to the quantity of groundwater in the Wepo aquifer in the vicinity of the N-14 TOJ parcel.

Moenkopi Wash courses near the southeastern edge of the N-14 mining area. The discussion of alluvial wells and their water levels under the J-16 Parcel subsection above is applicable to mining that occurred within the N-14 parcel, and include wells 87 23, 23R, 88, 89 and 89R (see Map 3.1.b). Based on the previous analysis for the J-16 TOJ parcel, impacts from mining in N-14 west of Moenkopi Wash on groundwater quantity in the alluvium along Moenkopi Wash were minimal.

Infiltration and Recharge. In 1991, Geotrans Inc. was retained to perform vertical infiltration tests in the N-2 and J-27 reclaimed areas and the J-3 undisturbed area. Of the 17 tests run in the N-2 and J-27 reclamation, vertical infiltration rates for replaced topsoil ranged from 5.1 to 14.5 cm/hr. and vertical infiltration rates for spoil ranged from 0.14 to 10.5 cm/hr. In contrast, vertical infiltration rates for undisturbed topsoil in J-3 ranged from 5.7 to 35.2 cm/hr. The results indicate 46 percent and 62 percent of the undisturbed topsoil infiltration rates exceed the infiltration rates of the replaced topsoil and spoil, respectively. The vertical infiltration properties of the N-2 and J-27 topsoil and spoil are believed to be representative of what would be measured in the J1/N6, J-16, and N-14 TOJ parcels. This fact is of little significance to the Wepo and spoil aquifers on the leasehold because Black Mesa is a recharge deficit area (evapotranspiration exceeds precipitation). At the Peabody leasehold, the mean annual evaporation is 45 inches. Between the months of May and October, monthly evaporation ranges from 2.7 to 11.5 inches, while average monthly precipitation only ranges from 0.35 to 1.7 inches. The monthly recharge deficit is quite significant even without considering transpiration losses. Considering the measurable depths to ground water in the Wepo formation, the potential for recharge via infiltration through the undisturbed soil, rock units, and spoil is negligible, except in areas of extensive burn and fracturing.

Recharge to mining areas that have intercepted the Wepo aquifer is principally reliant on horizontal flow from the surrounding undisturbed portions of the aquifer into the spoil material. The horizontal aquifer properties of the spoil area are equal to or exceed those of the surrounding undisturbed aquifer. In this regard, VanVoast and Hedges (1975) concluded that greater porosities and hydraulic conductivities would result from volume changes between the spoil material in its original compacted, stratified state and its rearranged state following replacement. In contrast, recharge to the alluvial aquifer occurs via horizontal flow from the Wepo aquifer, as well as infiltration through the channel beds and banks (channel transmission losses) during runoff events.

Spring Flow. Attachment 3-2 presents graphs of manual flow measurements collected at springs located adjacent to or within the J-1/N-6, J-16 and N-14 TOJ parcels. Natural springs (NSPG) 22, 61, 62 and 64 are located near Coal Mine Wash on undisturbed land west of the J-1/N-6 TOJ parcel (see Drawing 93500). Spring 22 was first monitored in February 2005, and has exhibited low flow rates less than 1.0 gallon per minute (gpm) through 2018 along with several periods of zero flow. Spring 61, located about 0.3 miles south of spring 22 and adjacent to Coal Mine Wash, was initially monitored for flow rate in early 2008. Flow rates at spring 61 typically range between 0.2 and 0.6 gpm, except for a maximum rate of about 3.6 gpm in February 2013. No flow has been observed at spring 61 since 2016 through 2018. Spring 62, located approximately 1.8 miles south of spring 61, was first monitored in 2010. Flow rates at spring 62 have been similar to spring 22, ranging from zero flow up to 0.9 gpm. Natural spring 64 is located in a small drainage to the north of the gravel pit near the southwest corner of the N-6 mining area (see Drawing 93500). Flow rates measured at spring 64 beginning in 2013 have been appreciably higher than springs 22, 61 and 63, and range between 1.6 and 7.9 gpm. Flow rates at all four springs appear to show some seasonal variability, and are sustained by localized recharge from nearby upgradient sources. As mentioned previously, mining in the N-6 pit was completed in 2008 followed by final reclamation (backfilling and grading) in 2012. Periods of zero flow at springs 22, 61 and 62 are likely due to periods of low localized precipitation and are not related to mining and reclamation in the N-6 pit. Flow rates at spring 64 are likely influenced by recharge from scoria materials that form the hillslopes and ridges just southwest of the N-6 pit, a portion of which has been mined in the nearby gravel pit for decades.

Natural springs 151 and 162 are located northwest of the J-16 pit (see Drawing 93500). Both springs emanate from shallow deposits of scoria and are sustained by localized recharge. Spring 151 was first monitored for flow in 2000, and based on manual flow measurements, has shown marked seasonal variability ranging from zero to 60 gpm through 2018 (see Attachment 3-2 and Figure 3, 2018 AHR (PWCC, 2019)). However, the spring is located at the inflow to Pond J16-E, and during periods of high runoff, water levels in the pond submerge the flow measurement location and no manual flow measurements can be collected. The relatively consistent record of low flow throughout the year at spring 151 indicates periodic contributions from shallow clinker beds nearby provide the flow source, not the deeper Wepo formation that was mined to the east at J-16. Greatly increased flow rates at spring 151 also occur from time to time following major precipitation events. Spring 162 was first monitored for flow in 2003. Flow rates at spring 162 have ranged between zero and 0.5

gpm, and have been dry for extended periods since monitoring began. The most recent flow rate measured at spring 162 occurred in March 2013. However, pooled water in a temporary cistern at the spring or damp conditions in the surrounding area have been observed at this spring through 2018. Spoil spring (SSPG) 150 was discovered in the middle portion of the J-16 pit in October 1999, flowing at less than 0.01 gpm. Spoil spring 150 flowed at 1 gpm in November 2000, and has since been dry through 2018. The flow measurements collected at natural springs 151 and 162 do not indicate mining and final reclamation of the J-16 pit has impacted either spring. Based on the minimal flow rates and lack of persistence, spoil spring 150 appears to have been a short term expression of surface discharge from a localized source, and will likely disappear permanently as reclamation matures in the J-16 reclaimed landscape.

Two natural springs were found north of the N-14 pit in 1980, springs 97 (see Drawing 85600) and 111 (see Drawing 93500). Spring 97 was located in the northwest corner of the N-14 pit, and exhibited low flow rates ranging from 0.13 to 0.53 gpm until it was mined out in 1984. Two additional springs located upgradient of the N-14 pit to the north were monitored for flow at the request of OSM in 1999; Goat Spring #2 and Hogan Spring (see Drawing 85600). Flow rates at both springs were minimal, ranging from 0.0004 to 0.2 gpm at Goat Spring #2 and from 0.0003 to 0.01 gpm at Hogan Spring. Natural spring 111 has been monitored for flow for more than 30 years until OSM approved idling the spring for monitoring purposes in 2014 (see Attachment 3-2). Flow rates at spring 111 were typically less than 0.2 gpm over its monitoring record, with two instances of higher flows of 2 gpm in 1987 and about 1.1 gpm in 2008. Based on its long term flow rate monitoring history, mining activities in the N-14 pit had no effect on flow at spring 111 or the two other natural springs near spring 111 to the north of the N-14 pit.

Ground Water Quality

Both analytical and graphical techniques were used to evaluate ground water quality impacts to the Wepo and alluvial aquifers hydraulically downgradient from the J-1/N-6, J-16, and N-14 TOJ parcels. Wepo and alluvial wells discussed in the previous section entitled “Ground Water Flow, Levels, and Gradient” are the primary focus of discussions and analysis of ground water quality impacts in the following sections. Analysis techniques employed for impact assessments include statistics (means and ranges) compiled using water quality data collected from monitoring wells for the period of record considering both uncensored and censored data. The period of record consists of water quality data collected beginning January 1, 1986 through 2018, unless the well was constructed more recently, or in a few cases, was idled or reclaimed. Comparisons of chemical constituent concentrations with applicable water quality standards as provided in the most current AHR (PWCC 2018) were also evaluated. Where instructive, differences between up and downgradient chemical parameter concentration means and ranges are discussed including recent values of total dissolved solids (TDS) concentrations. Graphical analysis techniques include trilinear diagram plots and Sen estimate of trend slope plots. Trilinear diagrams and Sen estimate of trend slope plots were constructed to assess water types, changes toward different water types, degree of variability, persistent increasing trends in parameter concentrations for the period of record, and recent trends. The nonparametric Sen trend analysis was used because it is fairly resistant to outliers.

The mining process does not require the use of chemicals that do not occur naturally at the site. Typical chemical reactions and byproducts from the pits where portions of the Wepo aquifer were intercepted include: (1) pyrite oxidation and buffering and the dissolution of gypsum which results in increases in calcium (Ca), magnesium (Mg), sulfate (SO_4), bicarbonate (HCO_3,) and TDS concentrations; and (2) cation exchange reactions on the clays resulting in potential increases in Na, Ca, and Mg concentrations. Because these same chemical constituents are naturally occurring, concentration changes and trends in the upgradient wells were evaluated to account for naturally occurring processes and possible trends resulting from climatic factors. The proximate upgradient wells were important in determining the water use potential of the Wepo aquifers in the vicinity of the J-1/N-6, J-16, and N-14 TOJ parcels. Water quality data for the above-referenced wells can be found in previously submitted AHRs.

J-1/N-6 TOJ Parcel. Table 3.2 lists the concentration means and ranges for the chemical constituents most likely to change in concentration during and following mining activities within the J-1/N-6 TOJ parcel. In addition, means and ranges for the two trace metals F and Se are presented in Table 3.2. Where applicable, ranges include censored data. Hydraulically upgradient well 53, representing background in the Wepo aquifer, is distinguished from downgradient wells 40, 43, 43R and 44. Comparing upgradient water quality with downgradient water quality provided in Table 3.2, it is apparent that for a majority of the parameters, downgradient wells 40, 43, 43R and 44 exhibit lower concentrations of Na, SO_4 and TDS. Differences in Ca at wells 43 and 43R and fluoride (F) in wells 40 and 44 compared to levels measured at upgradient well 53 can be attributed to localized conditions at all four downgradient wells. Wells 43 and its replacement 43R are influenced by localized recharge in the surrounding scoria, and well 44 has shown relatively higher levels of F compared to wells 53, 43 or 43R for its period of record. Selenium levels in Wepo wells proximate to the J-1/N-6 TOJ parcel are negligible.

Alluvial wells 17 and 200 are located along upper Coal Mine Wash and are upgradient of the J-1/N-6 TOJ parcel. Alluvial wells 80R, 193, 83 and 197 are currently located downgradient of the J-1/N-6 TOJ parcel along Coal Mine Wash. Well 80 was installed in 1980 near the current location of its replacement well 80R. Comparing upgradient alluvial water quality with downgradient, it is apparent that the mean concentrations for six parameters (Ca, Mg, Na, SO_4, HCO_3 and TDS) are higher downgradient along Coal Mine Wash, and tend to increase downstream to well 83. However, the maximum values of all six parameters measured in well 200 are all higher than any maximum value measured in the downgradient wells. The relatively high maximum concentrations in well 200 suggest that water quality in the upgradient alluvium along Coal Mine Wash occasionally exhibits concentrations much higher than measured downstream due to natural causes. Fluoride levels are relatively low and are comparable upgradient and downgradient along Coal Mine Wash. Selenium (Se) in upgradient well 200 is much higher than in downgradient wells, although the most downstream well 197 has a higher mean selenium concentration than exhibited in all other downgradient wells, and suggests localized alluvial materials contribute to the higher values seen upgradient at well 200 and the most downgradient well 197.

The reach of Coal Mine Wash beginning at well 80R downstream to the NR 41 crossing and about 0.5 miles further downstream features a dense growth of tamarisk. PWCC believes the culverts at the NR 41 crossing have constricted larger runoff events over decades, allowing larger runoff events to submerge areas along the first terraces of Coal Mine Wash upstream, depositing sands, silts and clays and maintaining shallow water tables for tamarisk trees to grow more densely. Over time, alluvial groundwater along this reach and downstream features higher concentrations of Ca, Mg, Na, HCO_3, sulfate and TDS due to natural geochemical reactions including dissolution of gypsum, cation exchange and cyclic evaporative effects due to dense tamarisk growth. In addition, the constricted flow at NR 41 has reduced the overall gradient of Coal Mine Wash in this reach. The lower channel gradient has slowed larger runoff events and reduced the tractive forces of large events that, in similarly sized reaches of other washes on Black Mesa (e.g., Upper Moenkopi Wash), tend to maintain a well-defined incised main channels with relatively high steep banks and relatively sparse vegetation.

Attachment 3-3 provides trilinear diagrams for Wepo and alluvial monitoring wells in the vicinity of the J-1/N-6 TOJ area. Upgradient well 53 exhibits a NaSO4 water type over the period of record, shifting to a NaHCO3SO4 water type over the last 5 years and relatively stable TDS concentrations. Downgradient well 44 features a NaHCO3 water type consistently with minimal fluctuations in TDS. Well 40 showed a NaHCO3 water type from 1986 to 2006, then shifted to a NaSO4HCO3 water type through 2018. TDS at well 40 has been relatively stable since 2010. Well 43 exhibited a NaSO4HCO3 water type with occasional shifts and TDS fluctuations during its early history until it was removed due to the expansion of the nearby gravel pit. Well 43R (Well 43 replacement) has shown variability in water types over the period of record largely dominated by HCO3 and mixed cations, most recently MgNaCaHCO3. TDS levels at well 43R have fluctuated less than 40 mg/L over the last 5 years. Although water types differ among all five wells, no significant changes have been detected recently, and TDS levels are relatively stable.

Water types in alluvial wells located along Coal Mine Wash are dominated by sulfate and feature mixed cations over their periods of record. Upgradient well 17 has shown a NaMgCaS04 water type since 2007 and variable TDS less than 3,200 mg/L. Upgradient well 200 exhibited a MgCaSO4 water type for most of its period of record with TDS generally less than 2,000 mg/L, with the exception of the March 2008 sample with a water type of MgSO4 and a TDS of 13,900 mg/L. Well 200 is located upgradient of all mining related activities, and the March 2008 sample indicates localized natural conditions can result in high concentrations of certain chemical constituents in saturated alluvium along upper Coal Mine Wash for short periods on occasion. Progressing downgradient, well 80 exhibited a CaMgSO4 water type and TDS less than 4,000 mg/L from 1986 through 1988 until it was replaced with well 80R. Water types at well 80R were dominated by SO4 with mixed cations, and have shifted to a NaCaMgSO4 water type since 2012 with an increasing trend in TDS above 5,000 mg/L. Wells 193 and 83, located downstream of well 80R along Coal Mine Wash, also show water types dominated by SO4 with mixed cations. Well 193 has shown a CaNaMgSO4 water type since 2010, and well 83 has shown the same water type consistently over most of its long period of record. Both wells feature overall increasing trends in TDS, with maximum values at both wells seen in August 2015 when TDS at well 193 was 9,280 mg/L and well 83 was 10,400 mg/L. These maximum TDS values likely reflect evaporative effects and localized chemical reactions (dissolution of gypsum and cation exchange). TDS at both wells have been relatively stable and lower after 2015. Well 197 is the furthest downgradient alluvial well along Coal Mine Wash, located several tenths of a mile upstream with its confluence with Yellow Water Canyon Wash. As with all upstream alluvial wells, its water type is dominated by sulfate with mixed cations. The highest TDS measured at well 197 occurred in 2002 (7,730 mg/L), and has been less than 7,000 since 2014 through the present. Of note, the high TDS values seen at upgradient wells 83 and 193 in August 2015 were not apparent further downstream at well 197.

Attachment 3-4 provides Sen estimates of trend slope plots for Na, TDS, SO_4, and HCO_3 using data for the period of record for Wepo wells 53 (upgradient), 40, 43, 43R and 44 (downgradient). Well 53 shows decreasing trends for Na, TDS and SO_4, and an increasing trend for HCO_3. Well 40 exhibits overall increasing trends for Na, TDS, SO_4 and HCO_3, although recent values indicate decreasing trends in all four constituents. No trend existed for Na in well 43 prior to its replacement with well 43R, while both TDS and SO_4 were decreasing overall, and HCO_3 showed a slight increasing trend. Increasing trends for HCO_3 absent positive trends for Na, SO_4 and TDS indicate influence from local near-surface recharge. Well 43R shows negative trends for both Na and HCO_3 no trend for TDS and a positive trend for SO_4 although recent values have been declining. Well 44 shows declining trends in Na, TDS and HCO_3. Sulfate shows no trend at well 44.

Upgradient alluvial wells 17 and 200 show increasing trends for all four constituents (Na, TDS, SO_4 and HCO_3) for their periods of record. Further downstream along Coal Mine Wash and downgradient of the J-1/N-6 TOJ parcel, well 80R also shows increasing trends for all four constituents since monitoring began in 1988. No trend analyses were performed for well 80 due to its short period of record (1986 to 1988). Further downstream, well 193 also shows increasing trends for all four constituents. However, positive trends were determined only for Na and HCO_3 at well 83 located upstream near the NR 41 crossing. Well 83 showed no trend for TDS and a negative trend for SO_4. Positive trends were determined for all four constituents at well 197 (furthest downgradient). However, recent data collected at well 197 indicates recent concentrations of Na, TDS, SO_4 and HCO_3 have been slightly lower than historical values.

The trend analyses indicate no significant changes such as recent and persistent increasing trends in water quality have occurred in the Wepo aquifer as a result of mining activities in the J-1/N-6 TOJ parcel either upgradient or downgradient. The analyses also indicate increasing trends in water quality are evident for both upgradient and downgradient alluvial wells. High levels of TDS and sulfate in downgradient wells have also been measured in at least one upgradient well over the period of record. The increasing trends and concentrations of constituents analyzed progressing downgradient along Coal Mine Wash are likely due to localized conditions including dense tamarisk growth and constricted flow at NR 41, and are not caused by mining within the J-1/N-6 TOJ parcel.

Lastly, the 2018 AHR provides an assessment of the potential to use Wepo and alluvial aquifer water to provide livestock drinking water based on a comparison of water quality data collected at all currently monitored Wepo and alluvial wells, including Wepo wells 40, 43R, 44 and 53, and alluvial wells 17, 200, 80R, 193, 83 and 197. Based on this assessment, water quality measured in all wells analyzed in the vicinity of the J-1/N-6 TOJ parcel are suitable for livestock drinking water. Mining activities associated with the J-1/N-6 TOJ parcel has not impacted the use potential of the Wepo or alluvial aquifer in the vicinity to support the intended postmining land use of livestock grazing.

J-16 TOJ Parcel. Table 3.3 lists the concentration means and ranges for the chemical constituents most likely to change in concentration during and following mining activities within the J-16 TOJ parcel. In addition, means and ranges for the two trace metals F and Se are presented in Table 3.3. As with Table 3.2, ranges include censored data where applicable. Well 44, discussed in the previous section and included in Table 3.3, is referenced as a downgradient well for water quality purposes. Table 3.3 provides data collected from Wepo wells located upgradient of the J-16 TOJ parcel, wells 62 and 62R. Comparing downgradient water quality at well 44 with upgradient water quality for well 62 and its replacement well 62R, it is apparent that downgradient well 44 exhibits lower concentrations of Na, Mg, Na, SO_4, and TDS. Bicarbonate in downgradient well 44 is higher than values seen in well 62, and comparable to values measured in well 62R. Fluoride values in well 44 are more than double than those measured in both wells 62 and 62R. No measurable selenium has been measured in either upgradient well 62 or 62R, and is at low concentrations at downgradient well 44.

Alluvial wells 87 and 23R are currently located along upper Moenkopi Wash and are upgradient of the J-16 TOJ parcel and all mining related activities. Well 23R serves as a replacement for well 23. However, well 23R has been dry for all practical purposes since it was installed in 1993, and no water quality data is available from this well. Accordingly, water quality collected at well 23 is used in the following sections for comparison purposes. Alluvial well 89R is currently located downstream of well 23R and downgradient of the J-16 TOJ parcel along Moenkopi Coal Mine Wash and serves as a replacement for wells 88 and 89. Well 87 was installed along upper Moenkopi Wash in 1980. Values of TDS in well 87 fluctuated from year to year but were less than 4,000 mg/L up through 2004. Thereafter, TDS increased significantly for several years (maximum value of 15,100 mg/L in 2007). Recent TDS values (2015 to present) have been less than 5,000 mg/L. Due to its location, the variability and overall increase in TDS and other constituents in well 87 from 2005 through 2014 are related to natural conditions and localized chemical reactions upgradient of mining activities. Water quality data collected in well 23 are limited to the period 1986 through 1991, and show much lower means and ranges of concentrations compared to well 87 and downgradient wells 88, 89 and 89R.

Well 88 was a 4-inch diameter well installed in 1980 near the main channel of Moenkopi Wash, and well 89 was a 2-inch well installed in the vicinity of well 88 but about 100 feet from the main Moenkopi Wash channel. Mean values of all constituents except for F and Se at well 88 were slightly higher than at well 87 and at both wells 89 and 89R. Maintenance problems encountered with well 88 and potential over-drilling into the Wepo Formation at well 89 prompted the decision to abandon both wells. Well 89 featured low concentrations of all parameters until it was replaced with well 89R in 1988. Well 89R features mean values of Ca, Mg, Na, SO_4, and TDS comparable to those measured at upgradient well 87, and maximum values for these parameters at 89R are appreciably lower than well 87. Of note, selenium concentrations at well 89R have averaged 1.1 ug/L over its period of record, more than two times lower than well 87. Well 27R is currently located downgradient and south of the J-16 TOJ parcel along Reed Valley Wash, and serves as a replacement for well 27. Mean values and concentration ranges for well 27 up until it was replaced by well 27R in 1989 were relatively low compared to well 27R and well 89R on Moenkopi Wash. Well 27R features higher mean values compared to wells located on Moenkopi Wash downgradient of the J-16 Moenkopi Wash. However, maximum values of Ca, Mg, HCO_3 and F are lower than at well 89R, and maximum values of Na, SO_4 and TDS at well 27R are higher than seen at well 89R yet within the same of order of magnitude for each constituent compared.

Attachment 3-3 provides trilinear diagrams for Wepo and alluvial monitoring wells in the vicinity of the J-16 TOJ parcel. Upgradient Wepo well 62 featured mixed cations dominated by sulfate for water types, shifting to a NaHCO3 water type into 1998 after which it was replaced with well 62R. TDS values in well 62 were commonly greater than 4,000 mg/L, although values less than 3,000 mg/L occurred historically. Well 62R water types typically showed sodium as the dominate cation, with both HCO3 and SO4 as dominant anions up until 2004. Thereafter, the water type has consistently been NaSO4 accompanied by a gradual decline in TDS to less than 1,900 mg/L since 2015. As mentioned previously, upgradient well 44 exhibits a NaHCO3 water type and stable TDS concentrations. Upgradient alluvial well 87 has exhibited multiple water types over its long period of record. Sulfate has dominated most water types with a variety of mixed cations. For its short period of record, upgradient well 23 featured a NaMgCaSO4 water type and low TDS. Downgradient well 88 exhibited mixed cations with sulfate dominant, and a steady NaCaMgSO4 water type along with relatively high TDS from 1995 until monitoring stopped in 2001. Well 89 showed a water type of CaMgSO4 and low TDS for its short period of record (1986-1988). Currently monitored well 89R exhibits a consistent water type of NaCaMgSO4 with TDS levels less than 5,000 mg/L. Recent TDS concentrations at 89R have been less than 3,800 mg/L. Well 27, located downgradient of the J-16 TOJ parcel along Reed Valley Wash to the south, exhibited a MgCaNaSO4 water type and low TDS for its short period of record. Up until the well was idled for monitoring purposes, well 27R featured a CaNaMgSO4 water type consistently with no appreciable shifts. TDS at well 27R ranged greater than 5,000 mg/L from 1994 through 2002.

Attachment 3-4 provides Sen estimates of trend slope plots for Na, TDS, SO_4, and HCO_3 using data for the period of record for Wepo wells 62 and 62R (upgradient). No trends were found at well 62 for any of the four parameters analyzed. Well 62 shows no trend for Na, decreasing trends for both TDS and SO_4, and an increasing trend for HCO_3. The positive HCO_3 trend absent increasing trends for Na, SO_4 and TDS indicates recharge contributions from near surface sources. As mentioned in the previous section, well 44 is located downgradient of the J-16 TOJ parcel, and shows negative trends for both Na and TDS, no trend for SO_4, and an increasing trend for HCO_3.

Alluvial well 87 shows positive trends for all four parameters, indicating natural causes due to its upgradient location with respect to all mining activities including those associated with the J-16 TOJ parcel. No trends were determined for Na, TDS and SO_4 at well 23 although its water quality record is relatively short term. Downstream at well 88 (downgradient), no trend was determined for Na, and positive trends were found for TDS, SO_4 and HCO_3. Currently monitored well 89R shows a negative trend for Na, no trends for either TDS and SO_4, and a positive trend for HCO_3. Downgradient well 27R on Reed Valley Wash shows positive trends for all four parameters through 2002 when it was idled for further monitoring.

As mentioned above, the 2018 AHR provides an assessment of the potential to use Wepo and alluvial aquifer water to provide livestock drinking water based on a comparison of water quality data collected at all currently monitored Wepo and alluvial wells, including Wepo wells 44, 62 and 62R, and alluvial wells 87 and 89R. Based on this assessment, water quality measured in all wells analyzed in the vicinity of the J-1/N-6 TOJ parcel are suitable for livestock drinking water. Mining activities associated with the J-16 TOJ parcel has not impacted the use potential of the Wepo or alluvial aquifer in the vicinity to support the intended postmining land use of livestock grazing.

N-14 TOJ Parcel. Table 3.4 lists the concentration means and ranges for the chemical constituents most likely to change in concentration during and following mining activities within the N-14 TOJ parcel. In addition, means and ranges for the two trace metals F and Se are presented in Table 3.4. As with Tables 3.2 and 3.3, ranges include censored data where applicable. No upgradient Wepo monitoring wells were completed and monitored north of the N-14 mining area. Wepo wells 49 and 54 were installed downgradient of the N-14 mining area in 1980 and are currently being monitored. Well 49 is located south of the eastern portion of N-14, and well 54 is located southwest of the N-14 area (see Drawing 93500). Water quality at both wells feature comparable means and ranges of all parameters. The means and ranges of Ca and HCO_3 at both wells 49 and 54 are comparable to those measured at upgradient well 87, and means and ranges of Na, SO_4 TDS, F and Se are all lower than well 87. In addition, water quality at both wells 49 and 54 are comparable to or below the means and ranges measured at downgradient alluvial well 89R.

Attachment 3-3 provides trilinear diagrams for Wepo and alluvial monitoring wells in the vicinity of the N-14 TOJ parcel. Downgradient well 49 featured a MgCaSO4 water type consistently over its period of record except for one shift to a NaMgCaSO4 type in 1995. Well 54, also located downgradient of the N-14 mining area, has shown six different water types over its history, with the most recent type of CaMgHCO3SO4. The most predominant type has been MgCaHCO3SO4. TDS has not exceeded 1,510 mg/L in either well. Water types for upgradient and downgradient alluvial wells located along Moenkopi Wash are discussed in the preceding section under the J-16 TOJ Parcel.

Attachment 3-4 provides Sen estimates of trend slope plots for Na, TDS, SO_4, and HCO_3 using data for the period of record for Wepo wells 49 and 54 (downgradient). No trends were determined at well 49 for TDS and HCO_3 and a negative trend was seen for SO_4. A slight positive trend was determined for Na, although the range of this parameter was comparatively low (15 to 97 mg/L). No trends were found for Na, SO_4 and TDS at downgradient well 54. A slight positive trend was found for TDS at well 54, yet concentrations of this parameter have been less than 1,500 mg/L over its lengthy record.

As mentioned above, the 2018 AHR provides an assessment of the potential to use Wepo and alluvial aquifer water to provide livestock drinking water based on a comparison of water quality data collected at all currently monitored Wepo and alluvial wells, including Wepo wells 49 and 54. In addition, the previous section under the J-16 TOJ Parcel addressed all currently monitored alluvial wells along Moenkopi Wash that are either upgradient or downgradient of the N-14 TOJ parcel. Based on this assessment, water quality measured in all wells analyzed in the vicinity of the N-14 TOJ parcel are suitable for livestock drinking water. Mining activities associated with the N-14 TOJ parcel has not impacted the use potential of the Wepo or alluvial aquifer in the vicinity to support the intended postmining land use of livestock grazing.

Surface Water Quantity

PWCC initiated a Small Watershed Study (SWS) monitoring program on Black Mesa in 1985. Details regarding study objectives and monitoring associated with the study are provided in Attachment 4 in Chapter 16, Hydrologic Monitoring Program in the AZ-0001F Permit. Several small watersheds located within reclaimed and undisturbed areas were instrumented with supercritical flow flumes and continuous flow recorders for collecting runoff, sediment and water quality data. Rainfall data were collected using Belfort automated tipping bucket rain gauges located at the centroids of each watershed and direct reading rain gauges set up at various locations within each watershed. Total overland runoff and sediment yield data for individual storm events were collected from hill slopes in each watershed using runoff plots. The data results were utilized to calibrate a physically-based runoff and sediment yield model EASI, Erosion And Sediment Impacts (Zevenbergen et al. 1990; WET 1990) that has been used to support both TOJ applications for mined areas reclaimed under the initial program rules (30 CFR Part 715) and bond release applications for mined areas reclaimed under the permanent program rules (30 CFR Part 816).

The model was calibrated and verified using a two-step process and site-specific data collected as part of the Small Watershed Study. The EASI model was first calibrated and validated using total runoff volumes and sediment yields measured in the runoff plots along with rainfall data, followed by simulation of actual runoff hydrographs and corresponding sediment concentrations collected from the flumes considering measured storm durations and intensities. Soils and vegetative cover data measured in each plot and at select points in each watershed were also used in the model development process. Parameters that influence the model's predictions of runoff and sediment were calculated from observed data or estimated through model testing. Other theoretical parameters such as rainfall interception storage and Manning's "n" were estimated based on previous experience in the application of EASI at other surface mines in the Colorado Plateau region (WET, 1990).

The modeling results were used to support the first TOJ application submitted for the Kayenta Complex in March 1994 for the N-1/N-2 and J-27 interim program reclaimed areas (PWCC, 1994). The 1994 TOJ application included the final report for the modeling project completed in August of 1993 (RCE, 1993). The final report provides an in-depth discussion of the SWS data used for calibration, the calibration and verification process, as well as the modeling results for reclaimed parcels.

Following the 1994 TOJ application submittal, several EASI models were developed for additional reclaimed parcels located within the Kayenta Complex, including reclaimed watersheds upstream of temporary sediment ponds that were permitted as outfalls in the Kayenta Complex NPDES Permit No. NN-0022179. In the vicinity of the J-1/N-6 TOJ parcel, EASI models were developed for Ponds N6-C, N6-D and N6-F (August 2008), N6-G (April 2009), and both N5-D and N5-E (August 2009). The pond models (total area 346.4 acres) were used in support of re-classifying the six outfalls under the Western Alkaline Coal Mining (WACM) subcategory in the NPDES Permit. In addition, 1,533.3 acres of reclamation within the J-1/N-6 area were modeled using EASI in September 2009 in support of a TOJ application for the western portion of J-1/N-6 submitted in 2013. The total area of reclaimed areas previously modeled using EASI within or adjacent to the J-1/N-6 parcels totals 1,879.7 acres. Reclaimed areas totaling 148.5 acres upstream of Ponds J16-E and J16-F were modeled using EASI in August of 2008, including a portion of the J-16 reclaimed parcels subject to this TOJ application. In July 2008, an EASI model was developed for the majority of the reclaimed N-14 Coal Resource Area (CRA - 1,580.6 acres) and focused on reclaimed areas upstream of Ponds N14-F, N14-G and N14-H in support of re-classifying all three ponds under the WACM subcategory in the NPDES permit. The September 2009 model report for J-1/N-6 is provided in Attachment 3-5a. Attachment 3.5b contains the August 2008 EASI model report for ponds J16-E and J16-F, and the EASI model report for the N14 CRA (July 2008) can be found in Attachment 3-5c. Modeling assumptions, methods, results and interpretations are provided in each report. The modeling results provided in these reports are referenced in subsequent sections under each TOJ parcel section heading.

Runoff from reclaimed parcels associated with this TOJ application (J-1/N-6, J-16, and N-14) occurs as a result of rainfall or snowmelt. Two stream monitoring sites have been operated along the major channels downstream of these parcels for several decades. Site SW25 is located on lower Coal Mine Wash, and site SW26 is located on lower Moenkopi Wash. Runoff from the J-1/N-6 TOJ parcels may discharge to either SW25 or SW26 located approximately 10 and 7 miles downstream, respectively.

Runoff from the J-16 and N-14 TOJ parcels may discharge to SW26 located some 10 miles downstream. Streamflow at both sites is monitored using continuous stage recorders coupled with periodic measurements of channel cross sections in order to convert stage records to discharge values (see Chapter 16, Hydrologic Monitoring Program, AZ-0001F Permit). These data are reported to OSM in Hydrologic Data Reports submitted to OSM and other agencies on an annual basis.

Runoff at the two stream monitoring sites occurs as a result of rainfall, snowmelt and, in rare instances, baseflow. Rainfall results from either convective or frontal storms. The convective storms are very localized and intense and often occur as moving storms that only cross portions of the watershed. Frontal storms cover larger areas, are slow moving, and can incorporate alternating intense and light periods of rainfall.

J-1/N-6 TOJ Parcel. Attachment 3-5a contains the September 2009 EASI model report for reclaimed areas that are situated adjacent to or lie within the J-1/N-6 TOJ parcel. The report covers EASI modeling of 1,533.3 acres of reclaimed areas located in the eastern and central portions of the J-1/N-6 coal resource area (CRA) that are adjacent to portions of the J-1/N-6 TOJ parcel subject to this TOJ application. Many of the upper portions of larger watersheds that course through the J-1/N-6 TOJ parcel were incorporated in the September 2009 EASI model. Results provided in the J-1/N-6 EASI reports (Attachment 3-5a) are presented as average annual values, and runoff results are expressed as inches of runoff. The model predicts little difference in average annual runoff between pre-mining and post-mining (reclaimed) conditions, and indicates runoff generated from hill slopes and low-order channels established in the J-1/N-6 TOJ parcel will average about 0.42 inches per year. Although drainage areas varied between pre-mining and post-mining conditions, drainage densities and mean channel slopes were comparable. Total channel length is higher in the post-mining J1/N-6 CRA compared to pre-mining. Peabody expects the J-1/N-6 TOJ parcel to exhibit similar runoff as predicted in the September 2009 EASI model due to the proximity of the reclaimed areas modeled and the blending of topography and geomorphologic features within the entire reclaimed J-1/N-6 CRA. In addition, reclamation methods including Best Management Practices (BMPs) (e.g., vegetative cover) used for reclaiming the J-1/N-6 TOJ parcel were similar to those used in reclaimed areas evaluated in the September 2009 EASI model. Model predictions are made at “end points” established at the model boundaries that coincide with outlet channels including any locations of temporary sediment ponds, and in limited areas at the lowest point along hill slopes (See Attachment 3-5a). Model assumptions consider any small depressions, pre-existing ponds prior to mining, or any larger, internally draining structures that may exist within the TOJ parcel following completion of reclamation. As a result, predictions of post-mining runoff may be lower than pre-mining due to capture of runoff within the modeled areas. No small depressions existed within the J-1/N-6 TOJ parcel prior to mining. The presence of any pre-existing surface water structure within the

J-1/N-6 TOJ parcel cannot be verified (see Chapter 17, Protection of the Hydrologic Balance, AZ-0001F Permit). EASI predicts 0.42 inches for both conditions modeled in the portion of the J-1/N-6 TOJ parcel located west of the main access road (designated N6 East Central in Attachment 3-5a).

Runoff not trapped by small depressions or PIIs eventually flows towards either Coal Mine Wash toward the west, or Moenkopi Wash toward the east of the J-1/N-6 TOJ parcels from small-area reclaimed portions east of the main access road. As runoff enters the larger channel system downstream, additional inputs to streamflow from adjacent and larger tributaries may occur depending on the magnitude, extent and duration of the rainfall event generating flow. Further downstream, runoff off-site from the J-1/N-6 TOJ parcel may be lost due to infiltration along the larger sand bed channels. Runoff from the western portion of the J-1/N-6 TOJ parcel may be captured in permanent impoundments proposed to be left downstream in the post-mining landscape including Ponds J2-A and N5-G. Runoff from the eastern portion of the J-1/N-6 TOJ parcel not captured by small depressions or the two approved PIIs (J1-RA and J1-RB) will flow into Moenkopi Wash. This will now occur because the three temporary sediment ponds N6-C, N6-D, and N6-F previously located at or near the downstream limits of mining disturbance and reclamation in this area have all been removed and reclaimed. Chapter 18, Probable Hydrologic Consequences in Volume 11 of the AZ-0001F Permit provides an analysis of the potential impacts of leaving permanent impoundments in the post-mining landscape on downstream users. Due to several factors including very high transmission losses in the main channels and high variability of rainfall in the region, capture of runoff by the permanent impoundments will have negligible effects on downstream users.

J-16 TOJ Parcel. Attachment 3-5b contains an EASI model report for two ponds (J16-E and J16-F) that drain reclaimed areas situated adjacent to or lie within the J-16 TOJ parcels. The results indicate no difference in average annual runoff (0.42 inches) generated from reclaimed hill slopes and low-order channels established above both ponds compared to pre-mining conditions. Reclamation methods including BMPs (e.g., vegetative cover) utilized in the J-16 TOJ parcel were similar to those evaluated in the J16-E and J16-F EASI model. In addition, physical properties of the reclaimed watersheds above both ponds, including drainage density, channel lengths and gradients, and hillslope lengths and gradients were lower than pre-mining conditions characterized by highly dissected topography. Therefore, the EASI modeling results for the J16-E and J16-F ponds are considered to be representative of all reclaimed areas within the J-16 CRA.

As mentioned above, Chapter 18, Probable Hydrologic Consequences in Volume 11 of Permit AZ-0001F provides an analysis of the potential impacts of leaving permanent impoundments in the post-mining landscape on downstream users. However, there are no permanent impoundments proposed within the J-16 TOJ Parcel, and capture of runoff from the parcel will be negligible and have no effects on downstream users.

N-14 TOJ Parcel. Attachment 3-5c contains an EASI model report for the majority of the N-14 CRA. The model includes all TOJ parcels located within the boundary of the N-14 CRA. As mentioned previously, the EASI model results for the N-14 CRA provided in Attachment 3-5c are presented as average annual values, and runoff results are expressed as inches of runoff. The results indicate little difference in average annual runoff between pre-mining and post-mining (reclaimed) conditions. Runoff generated from hill slopes and low-order channels established in the N-14 CRA, including the TOJ parcel, will average about 0.42 inches per year. The N-14 CRA modeled assuming post-mining conditions is slightly smaller in extent (27 acres) compared to pre-mining conditions. Post-mining topographic features include higher drainage density and total channel lengths. However, mean channel slope, mean hill slope lengths and gradients are lower in the post-mining N14 CRA landscape. No ponds or small depressions existed within the N-14 TOJ parcel prior to mining. Pond N14-F is proposed to be left in the post-mining landscape within N-14 to serve as a viable source of water for supporting the post-mining land use of livestock grazing as discussed further in this document. No significant small depressions or internally draining permanent impoundments were created within the reclaimed N-14 CRA.

With regard to runoff within the N-14 TOJ parcel, the EASI model results provided in Attachment 3-5c show little difference in average annual runoff between pre-mining and post-mining (reclaimed) conditions and indicate negligible impacts have occurred regarding surface water quantity.

Surface Water Quality

Both analytical and graphical techniques were used to evaluate surface water quality impacts to runoff within and downstream of the J-1/N-6, J-16, and N-14 TOJ parcels. As previously mentioned, PWCC initiated a Small Watershed Study (SWS) monitoring program on Black Mesa in 1985, and details regarding study objectives and monitoring associated with the study are provided in Attachment 4 in Chapter 16, Hydrologic Monitoring Program in the AZ-0001F Permit. Several small watersheds located within reclaimed areas were instrumented with supercritical flow flumes, and water quality data collected at these sites are discussed in the following sections. In addition, water quality data collected at long-term monitoring sites established along the main channels near the southwestern extent of the leasehold are also discussed (SW25 and SW26, see Drawing No. 93500, Current Environmental Monitoring Sites, Volume 23, AZ-0001F Permit).

Analysis techniques employed for impact assessments include statistics compiled of water quality data collected from SWS flume sites and rainfall runoff data collected at the main channel stream monitoring sites for the period of record considering both uncensored and censored data. The period of record consists of water quality data collected beginning January 1, 1986 through 2018. Water quality data collected at the SWS flume sites only extends through 1991 when the monitoring program was discontinued. Comparisons of chemical constituent concentrations with water quality standards are also provided for available SWS flume-site water quality, and for the main channel stream monitoring sites as evaluated in the most current AHR (PWCC, 2019). Graphical analysis techniques including trilinear diagram plots and Sen estimate of trend slope plots are also utilized where instructive. Trilinear diagrams were constructed to assess water types, changes toward different water types, and degree of variability. Sen estimates of trend slope for select water quality parameters at the main channel stream monitoring sites are utilized to evaluate the presence of persistent increasing trends in parameter concentrations for the period of record, and recent trends. The nonparametric Sen trend analysis was used because it is fairly resistant to outliers.

No NPDES discharges from sediment ponds associated with the N-14 TOJ parcel have occurred over the period of record. Historically, there have been several discharges from sediment ponds located near the J-1/N-6 parcels, the majority of which were short-term, low-volume intentional discharges from Pond N6-L in order to maintain pond treatment capacity. In addition, one discharge that lasted for only 11 hours due to precipitation occurred from Pond J16-F in August 2013. The rates and volumes of the few NPDES discharges that have occurred from other sediment ponds located upstream of the main channel monitoring sites are several orders of magnitude lower than the runoff events in which water quality samples were collected at these downstream sites. These NPDES discharges were either completely infiltrated along the main sand bed channels before reaching the lower sites, or significantly diluted due the magnitudes of runoff in which they mixed as they flowed downstream. Consequently, water quality collected at the two downstream main-channel monitoring sites is considered representative of naturally occurring runoff. Water quality data collected at the SWS flumes was included with the Application for Release of Reclamation Liability N-1/N-2 and J-27 Interim Program Indian Lands (PWCC, 1994). Water quality data collected at the main channel stream monitoring sites can be found in previously submitted AHR's.

Runoff Water Quality. Table 3.5 lists the concentration means and ranges for the chemical constituents in surface water runoff that are used as indicators for comparison purposes and for determining whether impacts from mining activities have occurred. Data summaries are provided for SWS flume sites FLUM227 and FLUM228 (N-2 reclaimed area), FLUM267 and FLUM268 (N-6 reclaimed area), and FLUM277 (J-27 reclaimed area), and represent runoff water quality monitored in reclaimed areas including a portion of the J-1/N-6 CRA that lies east of the majority of the J-1/N-6 TOJ parcels. For comparison purposes, Table 3.5 also presents data summaries for the two main channel stream monitoring sites SW25 and SW26, and two baseflow monitoring sites located near the J-1/N-6 TOJ parcels (SW80R) and J-16 TOJ parcels (SW2A). Table 3.5 shows runoff monitored in all three reclaimed small watersheds exhibits comparable concentrations of the constituents listed, in particular very low concentrations of TDS and sulfate. The one high dissolved selenium value of 11 ug/L measured in 1990 at FLUM277 skews the mean presented, and most selenium concentrations in runoff from the reclaimed J-27 CRA were much lower or censored below the reporting limit, similar to runoff at other reclaimed SWS flume sites. Table 3.5 indicates rainfall runoff monitored at the downstream main channel sites exhibits higher concentrations of the constituents presented compared to reclaimed area runoff. Of note, TDS, sulfate, sodium, nitrate and selenium are all higher in runoff monitored downstream compared to runoff water quality measured in reclaimed areas at SWS flume sites.

Attachment 3-6 provides trilinear diagrams for SWS flume sites and the main channel stream monitoring sites SW25 and SW26. Runoff water types at SWS flume sites typically exhibit Ca as the dominant cation with variable percentages of the anions HCO_3 and SO_4. Mixed cation water types have been observed in runoff measured at FLUM267 and FLUM277. The main channel monitoring sites recently show similar water types (PWCC, 2019). During 2018, SW25 exhibited a NaCaHCO3 water type and SW26 showed a CaNaHCO3 water type. Historical data collected at these sites shows variable runoff types over the period of record. Rainfall runoff measured at SW25 has shown fourteen different water types, and SW26 has exhibited eighteen different water types over the period of record. The most common water type of rainfall runoff at both sites has been NaMgCaSO4. However, variable water types in rainfall runoff at both sites since 1986 through 2018 do not indicate a persistent trend towards one water type or other.

Water quality data collected at the SWS flumes were compared to livestock watering standards established by the Navajo Nation EPA for surface water (NNEPA, 2008). Table 3.6 shows the results of these comparisons, and excepting total recoverable copper, lead and vanadium at select sites, all water quality collected in runoff at the SWS met livestock watering standards. A review of the data indicates the few values of total recoverable copper, lead and vanadium shown in Table 3.6 at levels greater than the livestock limit are suspect because the dissolved analyses for these analytes in the same samples were less than the reporting limit. Based on the comparisons, runoff from reclaimed areas monitored as part of the SWS program is suitable for livestock drinking water, which is the primary land use proposed for the reclaimed areas at the Kayenta Complex. Comparisons of laboratory analytical results from samples collected at the two downstream main channel sites (SW25 and SW26) in 2018 with NNEPA livestock watering standards indicates rainfall runoff downstream is not suitable for livestock use based on concentrations of trace elements lead and vanadium analyzed using the total method (refer to Table 38, PWCC, 2019). The total method involves acidification and hot digestion of unfiltered samples that can result in high concentrations of trace elements, especially in samples with high concentration of suspended solids as typically found in rainfall runoff monitored in the downstream main channels. Total suspended solids measured in the rainfall runoff samples collected at sites SW25 and SW26 in 2018 were in excess of 10,000 mg/L (see Appendix 19 in the 2018 AHR, PWCC, 2019), and likely influenced the high concentrations of total lead and vanadium that were above the livestock drinking water standards.

Attachment 3-7 provides Sen estimates of trend slope plots for NO_3, Na, TDS, SO_4, and HCO_3 using data for the period of record (1986 – 2018) for the main channel monitoring sites SW25 and SW26. No trends are seen at SW25 excepting a slight increasing trend in HCO_3. Interestingly, decreasing trends are evident at SW26 for Na, TDS, and SO_4, and both HCO_3 and NO_3 show no trend. The lack of positive trends in water quality data collected from rainfall runoff at main channel monitoring sites SW25 and SW26, excepting the slight increasing trend in HCO_3 at SW25, supports the proposition that rainfall runoff water quality monitored in the main channels downstream of reclaimed areas is representative of naturally occurring conditions. And, based on lower concentrations of water quality parameters compared to the rainfall runoff monitored downstream in the main channels, runoff from reclaimed areas established on mined lands at the Kayenta Complex will have no significant impact on receiving stream water quality, including runoff from areas associated with the J-1/N-6, J-16, or N-14 TOJ parcels.

Baseflow Quantity and Quality

Monitoring of flow and water quality has been conducted at two temporary baseflow monitoring sites SW2A and SW80R since 2004 and 2005, respectively. Site SW2A is located on Moenkopi Wash near alluvial monitoring well 89R, and Site SW80R is located on Coal Mine Wash near alluvial well 80R (see Maps 3.1.b and 3.2.a, respectively). Figures 3.1 and 3.2 are graphs of manual discharge measurements collected at SW2A and SW80R, respectively. Manual discharge at SW2A (Figure 3.1) ranged between periods of no flow lasting more than one year to almost 180 gallons per minute (gpm). Flow conditions at SW2A have been less than 55 gpm since January 2012 and no measurable flow was found during 2018, and appear to vary depending on localized rainfall and corresponding runoff events. Final reclamation activities at the N-14 CRA were completed by 1995, and at the J-16 CRA, final reclamation occurred in 2000. The reach of Moenkopi Wash where temporary site SW2A has been monitored has shown baseflow periodically since the early 1980s. Recent monitoring data suggests the reach continues to exhibit baseflow from time to time well after final reclamation of the N-14 and J-16 CRAs were completed, and suggests mining and reclamation activities in both CRAs including TOJ parcels subject to this application has had negligible effects on baseflow discharge along this reach of Moenkopi Wash.

Flow at measurable amounts has consistently been found at SW80R (Figure 3.2) since monitoring began at this site in August 2005, ranging from 0.25 gpm to a maximum of 158 gpm in April 2008. Recent measurements (post-2008) have varied in magnitude yet have been greater than 7 gpm through 2018 except for low flow conditions seen in July 2013 (0.25 gpm). Final pit closure of the J-1/N-6 CRA including backfilling and grading was completed in 2012. Manual discharge measurements at SW80R after July 2013 exceeded 7 gpm and were greater than 100 gpm from March 2016 through February 2017. The reach of Coal Mine Wash in which SW80R is located has featured baseflow for decades and can be considered a downstream extension of high alluvial water tables and periodic baseflow segments along Coal Mine Wash extending upstream for about 1 mile above the N-11 haul road crossing. Recent manual measurements of baseflow discharge at SW80R indicate mining and reclamation of the J-1/N-6 CRA including the TOJ parcels has had negligible impact on baseflow discharges in Coal Mine Wash.

As discussed previously, Table 3.5 lists the concentration means and ranges for the chemical constituents in surface water runoff that are used as indicators for comparison purposes and for determining whether impacts from mining activities have occurred. Data collected at sites SW2A and SW80R are included in Table 3.5, and the mean values and ranges for baseflow at both sites are higher than means and ranges of all constituents shown for rainfall runoff collected at downstream SW Sites SW25 and SW26, excepting nitrate ($NO_{3)}$ at SW80R. Not surprisingly, the magnitudes of means and ranges of all parameters measured at baseflow sites SW2A and SW80R are comparable to those measured in alluvial monitoring wells established near or upstream (background) of each temporary baseflow monitoring site. Table 3.3 includes data collected at alluvial wells 87, 88 and 89R along Moenkopi Wash, and indicates comparable means and ranges of most constituents measured at SW2A except for NO_3 and Se. Mean values of both constituents are higher at SW2A compared to the three alluvial wells, yet they are within the same orders of magnitude. Of note, the highest value of selenium (total recoverable) measured at SW2A (11 ug/L) remains well below the livestock drinking water standard of 50 ug/L. Table 3.2 includes data collected at alluvial wells 80 and 80R (near SW80R) and 200 (upstream). Means and ranges of all constituents measured at SW80R are comparable to or are slightly greater than those measured at wells 80 and 80R excepting mean Na and NO_3 values, which are about double those at wells 80 and 80R yet within the same order of magnitude. Of note, maximum values of Ca, Mg, Na, SO_4 TDS and Se measured at upstream alluvial well 200 are well above the maximum values measured downstream at baseflow monitoring site SW80R.

Attachment 3-6 provides trilinear diagrams for temporary baseflow monitoring sites SW2A and SW80R. Baseflow water types at both SW2A and SW80R have been relatively consistent. Both sites exhibit a NaCaMgSO4 water type over most of the period of record, similar to water types seen in alluvial wells located nearby or upstream (see Attachment 3-3). In addition, TDS values at both sites have been relatively steady.

Water quality data collected at the temporary baseflow monitoring sites have been compared to livestock watering standards established by the Navajo Nation EPA for surface water (NNEPA, 2008) in recent Annual Hydrology Reports (e.g., PWCC, 2019). Absent occasional total mercury concentrations reported to be less than the Method Detection Limit (MDL) set at the livestock standard of 2 ug/L, water quality collected in the two temporary baseflow monitoring sites meets livestock watering standards.

Attachment 3-7 provides Sen estimates of trend slope plots for NO_3, Na, TDS, SO_4, and HCO_3 using data for the relatively short periods of record at sites SW2A and SW80R. No trends are evident at SW2A for NO_3 or HCO_3, and negative trends exist for Na, TDS and SO_4. At SW80R, no trends are evident for Na and SO_4, and negative trends exist for NO_3, TDS and HCO_3. Based on the similar concentrations of baseflow with alluvial well water quality and the lack of positive or increasing trends in representative water quality parameters, mining in the J-1/N-6, J-16 and N-14 CRAs have had negligible impacts on stream baseflow near each CRA including the TOJ parcels within each CRA subject to this application. In addition, baseflow at both SW2A and SW80R remains suitable for livestock drinking water.

Sediment Yields

Soils replaced within the J-1/N-6, J-16, and N-14 TOJ parcels, surrounding undisturbed areas within the leasehold overall, and in the arid/semiarid Southwest typically lack cohesion. The channels consist of steep sided, deeply incised arroyos with loosely consolidated channel banks and fine-grained sand bed channels. Figure 3.3 from Blatt, Middleton, and Murray (1972), shows these types of soils (unconsolidated clay and silts and fine-grained sands) are easiest to keep in suspension. The gray band shown in Figure 3.3 represents the flow velocity ranges necessary to keep particle types and sizes in suspension. Above the gray band are the velocities necessary to erode or entrain soil particles, whereas velocities below the gray band would be insufficient to transport the particles and deposition would occur. The bandwidths for the clay and silt particle sizes are quite wide because considerably higher velocities are necessary to erode consolidated and cohesive clays and silts. For the unconsolidated non-cohesive silts and clays and fine-grained sands found on the leasehold, velocities of less than 2 feet/second will erode and keep the particles in suspension. Typical flow velocities measured in the stream channels on the leasehold including the main channels along Yucca Flat Wash, Coal Mine Wash, and Moenkopi Wash where monitoring sites SW155, SW25, and SW26 are located, respectively, range from 8 to 12 feet/second.

In the semiarid Southwest, much of the precipitation is effective in terms of producing runoff.

Most of the rainfall occurs in short-duration, very high intensity storms that rapidly overcome soil infiltration and generate larger amounts of runoff. Total annual rainfall on the PWCC leasehold ranges from 6 to 12 inches. Figure 3.4, from Langbein and Schumm (1958), shows the relationship of annual sediment yield to effective annual precipitation and cover in the U.S. Note the highest annual sediment yields occur where there is a combination of approximately 12 inches of effective precipitation and desert/shrub type cover. Both factors are consistent for the leasehold and for the undisturbed areas adjacent to the J-1/N-6, J-16, and N-14 TOJ parcels. As a consequence of the soil and rainfall characteristics and the vegetative cover for this geomorphic region, the flows on the leasehold more closely approximate debris flows than they do stream flows.

J-1/N-6 Sediment Yield Model. As mentioned previously, Attachment 3-5a contains the September 2009 EASI model report for reclaimed areas that are situated adjacent to or lie within the J-1/N-6 TOJ parcel. The report covers EASI modeling of 1,533.3 acres of reclaimed areas located in the eastern and central portions of the J-1/N-6 coal resource area (CRA) that are adjacent to portions of the J-1/N-6 TOJ parcel subject to this TOJ application. Many of the upper portions of larger watersheds that course through the J-1/N-6 TOJ parcel were incorporated in the September 2009 EASI model (referred to as the N6 East Central area). EASI model results provided in Attachment 3-5a are presented as average annual values, and sediment yield results are expressed as tons per acre. Sediment yield is the amount of eroded sediment that leaves the modeled area on an average annual basis and includes production from both hill slope areas and channel erosion. Erosion results are typically lower than sediment yield results because these numbers only represent sediment yield from hill slopes and sub-watersheds with minimal channel development and do not include erosion in channels. The September 2009 EASI model (J-1/N-6 East and Central) indicates the N6 East Central area, which is located west of the main access road, predicts average annual sediment yield (1.61 tons/acre/year) and erosion (0.65 tons/acre/year) values well below pre-mining model predicted values, largely due to more effective hydrologic cover and channel erosion control measures. The results also indicate runoff from the reclaimed J-1/N-6 TOJ parcel subject to this application will not contribute additional solids to receiving stream flows above established background levels.

J-16 Sediment Yield Model. EASI model results provided in Attachment 3-5b for two ponds (J16-E and J16-F) that drain reclaimed areas situated adjacent to or lie within the J-16 TOJ parcel are presented as average annual values, and sediment yield results are expressed as tons per acre. Again, sediment yield is the amount of eroded sediment that leaves the modeled area on an average annual basis and includes production from both hill slope areas and channel erosion. Reclamation methods including BMPs (e.g., vegetative cover) utilized in the J-16 TOJ parcel were similar to those evaluated in the J16-E and J16-F EASI model. The model predicts average annual sediment yield of 1.14 tons/acre/year for the combined post-mining watersheds above Ponds J16-E and J16-F, well below the predicted pre-mining sediment yield for both watersheds of 2.28 tons/acre/year. This is largely attributed to physical properties of the reclaimed watersheds above both ponds. Reclaimed drainage density, channel lengths and gradients, and hillslope lengths and gradients were lower than pre-mining conditions, characterized by highly dissected topography. The results also indicate runoff from the reclaimed J-16 TOJ parcel will not contribute additional solids to receiving stream flows above established background levels.

N-14 Sediment Yield Model. EASI model results provided in Attachment 3-5c for the N-14 CRA are presented as average annual values, and sediment yield results are expressed as tons per acre. As mentioned above, sediment yield is the amount of eroded materials that leaves the modeled area on an average annual basis and includes production from both hill slope areas and channel erosion. The model results for the N-14 TOJ parcel show 1.39 tons/acre/year for average annual sediment yield, approximately twenty-nine percent less than the pre-mining sediment yield of 1.95 tons/acre/year. Post-mining topographic features include higher drainage density and total channel lengths compared to pre-mining conditions. However, mean channel slope, mean hill slope lengths and gradients are lower in the post-mining N14 CRA landscape. More effective hydrologic cover, changes in geomorphic features compared to pre-mining, and channel erosion measures including lower channel slopes in the reclaimed landscape also contribute to predictions of lower average annual sediment yields. The results also indicate runoff from the reclaimed N-14 TOJ parcels subject to this application will not contribute additional solids to receiving stream flows above established background levels.

Permanent Impoundments

One permanent impoundment designated Pond N14-F exists within the N-14 reclaimed parcel included in this TOJ application. No permanent impoundments exist within the J-1/N-6 or J-16 TOJ parcels.

Water Levels and Water Persistence. Pond N14-F created within the N-14 TOJ parcel was monitored for water persistence beginning in 2003 as part of periodic pond inspections conducted quarterly through 2017. Maximum water volumes observed in Pond N14-F from 2003 through 2017 ranged from 6.4 acre-feet (2005) up to 24.9 acre-feet (2013). Annual average water volumes estimated for Pond N14-F from 2003 through 2017 ranged from 3.3 acre-feet to 16.0 acre-feet. Water in Pond 14-F has been persistent for more than 14 years following construction. Water persistence is largely dependent on precipitation, although a portion is likely contributed by shallow groundwater from upgradient sources.

Access Safety and Stability. All slopes leading to Pond N14-F are moderate (see Map 2.2.B, Tab 2) and should provide safe access for the livestock which will be using the area.

N14-F Water Quality. Monitoring of water quality in Pond N14-F was conducted during 1988 through 1991, and from 2000 through 2006. Table 3.7 also lists the concentration means and ranges for the chemical constituents measured in samples collected from Pond N14-F for comparison purposes and for determining whether impacts from mining activities have occurred. Table 3.7 shows average values of Mg, Na, SO_4 and TDS are higher than rainfall runoff yet are comparable to baseflow measured at both SW2A and SW80R. Average values of Ca and HCO_3 are lower than baseflow yet higher than rainfall runoff. Values of NO_3 and Se are both comparable to reclaimed area runoff. Maximum values of Ca, Mg, Na, SO_4 and TDS are higher than maximum values in reclaimed area runoff, rainfall runoff at the main channel sites and the two baseflow sites. The high maximum values are indicative of the effects of evaporation and transpiration on pond water quality during periods of low precipitation from time to time. Wetter periods and increased runoff tend to dilute the concentrations of the constituents in N14-F pond water.

Attachment 3-6 provides a trilinear diagram for Pond N14-F. Seven different water types have been observed at N14-F and are typified by mixed cations and are dominated by the SO_4 anion. The most comment water type is CaMgNaSO4. TDS data collected in Pond N14-F shows no apparent trend other than occasional high concentrations greater than 7,000 mg/L due to drier conditions.

Water quality data collected at Pond N14-F were compared to livestock watering standards established by the Navajo Nation EPA for surface water (NNEPA, 2008) in order to determine the suitability of water in the impoundment to support livestock grazing, the principal land use proposed for the N-14 TOJ parcel. Table 3.7 shows the results of these comparisons, and indicates water monitored in Pond N14-F met all livestock watering standards with the exception of seven out of seventeen analyses for total recoverable lead. Seven lead analyses were reported to be less than the practical quantitation limit (PQL) that was set by the laboratory at a higher value than the lead standard of 100 ug/L. The PQLs for total recoverable lead have varied over the period of record. Regardless, all seventeen total recoverable lead analyses from samples collected at Pond N14-F were reported to be less than the PQLs. Based on the comparisons, water monitored in Pond N14-F is suitable for livestock drinking water and will support the postmining land use of livestock grazing. Also, there is no potential for diminution of the water quality of adjacent landowners as the pond water quality is of similar quality to baseflow measured downstream at site SW80R. And, due to significantly higher discharge rates during rainfall runoff in the downstream main channels, occasional discharges from Pond N14-F will be appreciably diluted within relatively short distances.

Diminution of Adjacent Water Quantity. Peabody believes sufficient information has been submitted and evaluated by OSM in Hydrology Reports, Permits, and other documents to demonstrate that Pond N14-F will not result in the diminution of the quantity of water utilized by adjacent or surrounding landowners. Chapter 17 (Protection of Hydrologic Balance) of the AZ-0001F Permit presents detailed descriptions of pre-existing water sources within the leasehold, including those proximate to the J-1/N-6, J-16, and N-14 TOJ parcels. Drawing No. 85322 in Volume 20 of the AZ-0001F Permit shows the locations of all pre-existing livestock and wildlife watering structures. One pre-existing structure (DM-8) was purported to exist within or adjacent to the J-1/N-6 TOJ parcel prior to mining but could not be found through field surveys and review of aerial photography, so no protection or mitigation has been conducted for this structure.

As mentioned above, Chapter 18 (Probable Hydrologic Consequences) of the AZ-0001F Permit presents analyses of the potential impacts of the mining operation, including a section that discusses the effects of dams, sediment ponds, and permanent impoundments on downstream users. In this section of Chapter 18, an evaluation of drainage area associated with all permanent impoundments proposed to be left within the Moenkopi basin indicates the impoundments may restrict about 4.6 percent of the average annual runoff at the lower end of the basin. The internal impoundments may result in localized decreases in receiving stream runoff, but these will become less pronounced and unmeasurable further downstream, as lateral inflows from undisturbed basins will provide additional contributions to downstream runoff. Channel transmission losses, evapotranspiration, and other losses in the main channels further downstream along Moenkopi Wash would completely mask any runoff reductions from the smaller reclaimed areas on the leasehold. Water levels in alluvial wells adjacent and immediately downgradient in the alluvium from existing temporary sediment ponds show normal fluctuations in response to low and high stream flow years. There is no evidence of persistent diminished recharge to the alluvium from runoff, which would be potentially attributed to the loss of watershed area associated with either existing temporary sediment ponds or permanent impoundments. In addition, PWCC has no evidence that flood irrigation has been practiced along the reaches of Moenkopi Wash downstream of Pond N14-F. Monitoring of stream flows in the main channels within and just downstream of the leasehold for three decades has shown extremely high sediment concentrations, which would preclude flood irrigation practices due to high maintenance costs. Based on the above summaries, PWCC maintains these impoundments will not result in the diminution of the quantity of water utilized by adjacent or surrounding landowners.

Pond Sediment Accumulations. Pond sediment accumulation monitoring has been conducted at Pond N14-F periodically from 1995 through 2006. The original as-built capacity of Pond N14-F in 1982 was 61.1 ac-ft. The pond was remediated in 1985, and a subsequent resurvey in 1989 indicated a storage capacity of 74.11 ac-ft. In 2003 the spillway and dam crest were raised, and the pond capacity was increased to 81.93 ac-ft. Based on periodic measurements of pond capacity prior to 1995, and sediment accumulation monitoring from 1995 through 2002 (prior to raising the spillway and dam crest in 2003), the sediment accumulation rate was 0.08 ac-ft/year. The rate of sediment accumulation from 1995 through 2006 was 0.15 ac-ft/year. Based on historic (1995 – 2006) and recent pond bottom measurements collected at Pond N14-F, sediment accumulation in Pond N14-F is negligible.

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Table 3.1a

Measured Water Level Ranges at Wepo Monitoring Wells Within or Adjacent to the J-1/N-6, J-16 and N-14 Parcels

PWCC Well Id	Historic Water Level Range pre-1988 Min	Max	Historic Water Level Range 1988-1994 Min	Max	Historic Water Level Range 1995-2018 Min	Max	2018 Maximum (ft)	2018 Water Level Compared to 1/88-1/95 Levels (ft)	Maximum Predicted Drawdowns [b] (ft)	Date Well Abandoned
WEPO40	71.5	83.5	66.0	74.4	67.1	80.6	74.5	0.1	47	
WEPO43	134.4	147.3	134.7	140.2	135.3	138.9	-	-	-	3/13/1997
WEPO43R	-	-	-	-	127.2	142.2	131.2	-3.5 (a)	43	
WEPO44	183.5	214.1	177.7	187.3	162.7	180.9	162.7	-15.0	49	
WEPO49	4.3	9.8	1.8	5.7	0.1	3.0	0.2	-1.6	55	
WEPO53	37.6	72.1	46.4	54.7	54.8	73.2	69.7	15.0	65	
WEPO54	47.4	55.9	49.5	51.4	50.0	52.1	50.6	Within	60	
WEPO62	109.0	155.2	128.0	192.6	162.0	222.6	-	-	-	4/4/1998
WEPO62R	-	-	-	-	205.8	220.7	207.0	14.4 (b)	63	

Modified after Tables 2 and 3, 2018 Annual Hydrology Report (PWCC, 2019). Outliers have been removed from pre-1988 data.

Notes:

(a) 2018 maximum compared to 1988-1994 water level range measured at WEPO43.

(b) 2018 maximum compared to 1988-1994 water level range measured at WEPO62.

Table 3.1b

Measured Water Level Ranges at Alluvial Monitoring Wells Within or Adjacent to the J-1/ N-6, J-16 and N-14 Parcels

PWCC Well Id	Historic Water Level Range pre-1988		Historic Water Level Range 1988-1994		Historic Water Level Range 1995-2018		2018 Maximum (ft)	2018 Water Level Compared to 1/88-1/95 Levels (ft)	Maximum Predicted Drawdowns [b] (ft)	Date Well Abandoned
	Min	Max	Min	Max	Min	Max				
ALUV17	5.1	7.4	5.5	8.0	5.1	8.9	7.4	Within	53	
ALUV23	15.6	18.6	16.0	18.1	16.6	19.0	-	-	-	>7/9/01
ALUV23R			19.2	Dry	Dry	Dry	Dry	Within	53	
ALUV27	22.0	29.0	20.7	27.1	-	-	-	-	-	4/27/1993
ALUV27R (a)	-	-	21.5	26.7	26.3	29.5		-	-	
ALUV80	8.0	11.5	8.6	9.8	-	-	-	-	-	4/26/1993
ALUV80R	-	-	8.9	11.7	10.2	12.9	12.0	0.3	54	
ALUV83	0,9	3.4	1.0	3.4	-3.4	3.5	1.2	Within	40	
ALUV87	14.2	22.9	17.8	23.1	17.3	24.1	22.6	Within	45	
ALUV88	0.8	4.6	1.2	3.6	0.9	4.9	-	-	-	>8/9/01
ALUV89	5.0	8.9	5.3	7.7	-	-	-	-	-	4/27/1993
ALUV89R	-	-	2.5	5.0	-0.2	6.3	2.9	Within	61	
ALUV193	-	-	10.9	12.4	9.9	15.5	13.5	1.1	46	
ALUV197	-	-	10.3	13.2	11.8	24.9	14.4	1.2	32	
ALUV200	-	-	4.1	5.9	3.0	6.5	4.8	Within	53	

Modified after Tables 9 and 10, 2018 Annual Hydrology Report (PWCC, 2019). Outliers have been removed from pre-1988 data.

Notes:

(a) ALUV27R was idled in 2002.

Table 3.2

Means and Concentration Ranges for Select Parameters Measured at Alluvial and Wepo Wells Proximate to the J-1/N-6 TOJ Parcel

M = mean   R = range ; All values in mg/L except Se, which is in ug/L

		Ca	Mg	Na	SO_4	HCO_3	TDS	F	Se
Background Well Concentration Means and Ranges									
WEPO53	M	50	38	1167	2047	916	3851	3.43	1.67
	R	15-107	11-75	579-1436	1370-2676	769-1080	2950-4400	1.0-6.4	<1-<10
ALUV17	M	250	93	67	854	316	1532	0.5	1.8
	R	160-456	56-179	21-180	445-1840	237-380	872-3200	0.1-1.0	<1-<10
ALUV200	M	240	108	70	856	338	1570	0.49	37.3[1]
	R	145-766	52-1330	29-1130	380-7900	261-430	800-13900	0.2-0.7	1-300[1]
Downgradient Well Concentration Means and Ranges									
WEPO40	M	16	13	423	270	734	1008	8.41	N/A
	R	2-50	0.7-48	266-705	30-940	569-1070	650-2310	1.0-12	<1-<10
WEPO43	M	223	53	155	699	487	1213	1.1	N/A
	R	1-389	4-82	41-360	12-1087	273-893	590-1872	0.7-2.0	<1-<5
WEPO43R	M	128	54	164	264	747	1023	0.80	5
	R	62-177	23-75	112-333	110-410	161-339	924-1150	0.2-1.4	<1-5
WEPO44	M	5	1.4	649	154	1567	1581	11.4	1.5
	R	3.5-8	1-3	557-785	2-766	644-1865	1420-2615	8.9-23	<1-2
ALUV80	M	437	328	197	2370	394	3709	0.65	1
	R	382-517	296-386	180-214	2258-2511	342-442	3456-3976	0.4-1.1	<1-1
ALUV80R	M	469	280	214	2164	462	3784	0.59	1.85
	R	369-592	200-386	118-438	1600-2990	290-752	2864-5600	0.4-0.9	1-<10
ALUV193	M	557	359	542	3228	634	5675	0.6	1
	R	471-668	271-510	373-834	2250-4140	246-858	4088-9280	0.5-0.8	1-<5
ALUV83	M	510	541	690	4017	832	6931	0.58	1.3
	R	413-743	383-665	355-879	2910-5038	425-982	4630-10400	0.2-0.9	<.5-<10
ALUV197	M	544	517	643	4008	697	6754	0.63	4.7
	R	454-634	268-665	371-835	2760-4640	449-868	4720-7730	0.37-0.9	1-9.1

Notes: Mean values and ranges reported for Se are for the dissolved analytical form.

[1] Statistics are based on data reported between the MDL and PQL, and are biased due to two high dissolved selenium values measured at ALUV200 in March 2008 (300 ug/L) and April 2008 (56 ug/L). The majority of dissolved selenium values (86 percent) measured at ALUV200 were non-detects ranging from <1 ug/L to <5 ug/L.

Table 3.3

Means and Concentration Ranges for Select Parameters Measured at Alluvial and Wepo Wells Proximate to the J-16 TOJ Parcel

M = mean R = range ; All values in mg/L except Se, which is in ug/L

		Ca	Mg	Na	SO_4	HCO_3	TDS	F	Se
Background Well Concentration Means and Ranges									
WEPO62	M	426	384	892	3495	871	5957	0.49	N/A
	R	287-507	216-465	462-1570	2256-4760	581-1041	1994-7600	0.2-1.0	<1-<10
WEPO62R	M	48	10.7	714	512	1454	2110	3.5	N/A
	R	31-70	7-18	401-945	186-1130	280-1970	1330-2840	1.1-5.7	<1-<1
ALUV87	M	250	353	358	2373	393	3988	1.13	2.7
	R	114-604	52-1470	38-1570	340-9410	229-827	812-15100	0.6-1.8	1-14.4
ALUV23	M	179	70	75	644	271	1165	0.46	N/A
	R	164-191	61-84	65-100	591-726	251-305	996-1320	0.3-1.0	<1-<5
Downgradient Well Concentration Means and Ranges									
WEPO40	M	16	13	423	270	734	1008	8.41	N/A
	R	2-50	0.7-48	266-705	30-940	569-1070	650-2310	1.0-12	<1-<10
ALUV88	M	415	465	456	3332	447	5359	0.87	2.1
	R	353-583	265-540	375-674	2770-3830	54-562	4306-6130	0.6-1.3	<1-<10
ALUV89	M	233	149	76	1023	336	1695	0.72	N/A
	R	205-260	137-159	64-102	941-1171	315-356	1580-1990	0.5-1.0	<1-<1
AlUV89R	M	373	347	323	2538	413	4136	0.78	1.1
	R	309-451	293-450	243-445	1770-3120	268-514	3430-5510	0.59-1.6	0.9-1.6
ALUV27	M	155	77	223	845	291	1415	0.5	N/A
	R	141-166	53-101	181-269	681-957	262-310	1160-1570	0.28-.9	<1-<1
ALUV27R	M	354	446	641	3678	398	5797	0.66	3.0
	R	294-450	379-504	459-724	2939-4110	344-434	4912-6950	0.5-0.9	<1-<10

Notes: Mean values and ranges reported for Se are for the dissolved analytical form.

[1] Statistics are based on data reported between the MDL and PQL.

Table 3.4

Means and Concentration Ranges for Select Parameters Measured at Alluvial and Wepo Wells Proximate to the N-14 TOJ Parcel

M = mean R = range ; All values in mg/L except Se, which is in ug/L

		Ca	Mg	Na	SO_4	HCO_3	TDS	F	Se
Background Well Concentration Means and Ranges									
ALUV87	M	250	353	358	2373	393	3988	1.13	2.7
	R	114-604	52-1470	38-1570	340-9410	229-827	812-15100	0.6-1.8	1-14.4
ALUV23	M	179	70	75	644	271	1165	0.46	N/A
	R	164-191	61-84	65-100	591-726	251-305	996-1320	0.3-1.0	<1-<5
Downgradient Well Concentration Means and Ranges									
WEPO49	M	237	97	36	781	312	1393	0.24	N/A
	R	175-277	73-115	15-97	680-892	254-346	1240-1510	0.1-0.5	<1-1
WEPO54	M	200	114	57	690	454	1345	0.30	N/A
	R	154-224	94-130	34-139	600-785	405-550	1234-1490	0.1-0.6	<.1-<1
ALUV88	M	415	465	456	3332	447	5359	0.87	2.1
	R	353-583	265-540	375-674	2770-3830	54-562	4306-6130	0.6-1.3	<1-<10
AlUV89	M	233	149	76	1023	336	1695	0.72	N/A
	R	205-260	137-159	64-102	941-1171	315-356	1580-1990	0.5-1.0	<1-<1
ALUV89R	M	373	347	323	2538	413	4136	0.78	1.1
	R	309-451	293-450	243-445	1770-3120	268-514	3430-5510	0.59-1.6	0.9-1.6

Notes: Mean values and ranges reported for Se are for the dissolved analytical form.

[1] Statistics are based on data reported between the MDL and PQL.

Table 3.5

Means and Concentration Ranges for Select Parameters Measured at SWS Sites[1], Main Channel SW Sites[2], and Baseflow Sites[3]

M = mean R = range ; All values in mg/L except Se, which is in ug/L

		Ca	Mg	Na	SO_4	HCO_3	TDS	NO_3	Se
SWS Sites Concentration Means and Ranges									
FLUM227	M	26	6	3	40	88	120	0.67	1
	R	14-40	4-9	2-4	19-62	73-102	74-190	0.12-2.4	<1-1
FLUM228	M	7	6	2	41	127	129	0.28	N/A
	R	<5-7	2-10	<1-5	8-109	115-139	42-240	0.01-0.9	<1-<1
FLUM267	M	34	8	6	43	105	171	1.01	N/A
	R	23-48	3-11	4-10	21-64	71-134	100-200	0.22-2.1	<1-<1
FLUM268[3]	M	28	4	1	35	77	35	0.30	<1
	R	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
FLUM277	M	41	8	3	68	85	188	0.75	6.5
	R	7-66	4-14	1-5	21-140	66-110	64-320	0.5-1.1	<1-11
Main Channel SW Sites Concentration Means and Ranges[4]									
SW25	M	165	98	144	927	194	1597	2.23	10
	R	29-491	6-557	7-780	17-4880	66-1240	200-7750	0.16-20	1-38
SW26	M	120	50	66	493	126	954	2.11	5.3
	R	18-505	5-278	14-283	50-2700	68-372	190-3635	0.07-15	1-20
Baseflow Sites and Pond N14-F Concentration Means and Ranges									
SW2A	M	439	471	413	2987	505	5209	7.38	3.25
	R	396-537	332-561	311-563	2300-4450	173-613	4240-7070	0.2-11.6	1-11
SW80R	M	445	346	397	2584	554	4633	1.7	2
	R	344-516	246-393	218-531	1880-3110	241-681	3300-5300	0.03-4.9	2-2[5]
N14-F	M	295	327	567	2786	363	4706	0.43	1.67
	R	68-609	24-1050	44-1890	220-8230	73-835	440-13600	0.03-2.4	1-2

Notes: Mean values and ranges reported for Se are for the dissolved analytical form unless otherwise indicated.

[1] SWS Sites established in reclaimed parcels only.

[2] Means and ranges provided for Main Channel SW Sites are from water samples collected in rainfall runoff only, and only using uncensored data.

[3] Means and ranges provided for Baseflow Sites are from water samples collected in baseflow at temporary stream monitoring sites SW2A (Moenkopi Wash) and SW80R (Coal Mine Wash).

[4] Selenium means and ranges for Main Channel SW Sites are derived from uncensored total recoverable analytical results.

[5] Only three uncensored total recoverable selenium values detected over period of record.

Table 3.6 - Comparison of NNEPA Livestock Watering Standards (NNEPA, 2008) with Small Watershed Study Flume Site Water Quality Data

Analyte	Standard	Sites	No. Sites	Frequency	Exceedence Date Range	Exceedence Value Range	Exceedence Median
LIVESTOCK WATERING STANDARDS -- NNEPA (07/31/08) (TOJ ANALYSES NOV2012)							
Arsenic, Dissolved	0.00 - 200.00	0	none				
Arsenic, Total	0.00 - 200.00	0	none				
Boron, Dissolved	0.00 - 5000.00	0	none				
Cadmium, Dissolved	0.00 - 50.00	0	none				
Cadmium, Total	0.00 - 50.00	0	none				
Chromium, Dissolved	0.00 - 1000.00	0	none				
Chromium, Total	0.00 - 1000.00	0	none				
Copper, Dissolved	0.00 - 500.00	0	none				
Copper, Total	0.00 - 500.00	0	none				
Field Ph	6.50 - 9.00	0	none				
Lead, Dissolved	0.00 - 100.00	0	none				
Lead, Total	0.00 - 100.00	0	none				
NO3_NO2 Nitrogen_N	0.00 - 132.00	0	none				
Nitrate Nitrogen_N	0.00 - 132.00	0	none				
Ph At 25 Deg. Cent.	6.50 - 9.00	0	none				
Selenium, Dissolved	0.00 - 50.00	0	none				
Selenium, Total	0.00 - 50.00	0	none				
Total Recoverable As	0.00 - 200.00	0	none				
Total Recoverable Cd	0.00 - 50.00	0	none				
Total Recoverable Cr	0.00 - 1000.00	0	none				
Total Recoverable Cu	0.00 - 500.00	1	FLUM228	1/0/0/1	08/06/91-08/06/91	780.0000 - 780.0000	780.0000
Total Recoverable Pb	0.00 - 100.00	3	FLUM227	1/0/0/1	08/06/91-08/06/91	120.0000 - 120.0000	120.0000
			FLUM228	1/0/0/1	08/06/91-08/06/91	630.0000 - 630.0000	630.0000
			FLUM277	1/0/0/2	10/06/89-10/06/89	250.0000 - 250.0000	250.0000

Table 3.6 (Continued)

Analyte	Standard	No. Sites	Sites	Frequency	Exceedence Date Range	Exceedence Value Range	Exceedence Median
Total Recoverable Se	0.00 - 50.00	0	none				
Total Recoverable V	0.00 - 100.00	3	FLUM227	1/0/0/1	08/06/91-08/06/91	190.0000 - 190.0000	190.0000
			FLUM228	1/0/0/1	08/06/91-08/06/91	880.0000 - 880.0000	880.0000
			FLUM277	1/0/0/2	10/06/89-10/06/89	200.0000 - 200.0000	200.0000
Total Recoverable Zn	0.00 - 25.00	0	none				
Vanadium, Dissolved	0.00 - 100.00	0	none				
Vanadium, Total	0.00 - 100.00	1	FLUM267	1/0/0/2	08/29/86-08/29/86	250.0000 - 250.0000	250.0000
Zinc, Dissolved	0.00 - 25.00	0	none				
Zinc, Total	0.00 - 25.00	0	none				

Frequency = uncensored/between MDL&PQL/censored/no. samples, (B) = Between MDL&PQL range, (<) = Censored range

Table 3.7 - Comparison of NNEPA Livestock Watering Standards (NNEPA, 2008) with Pond N14-F Water Quality Data

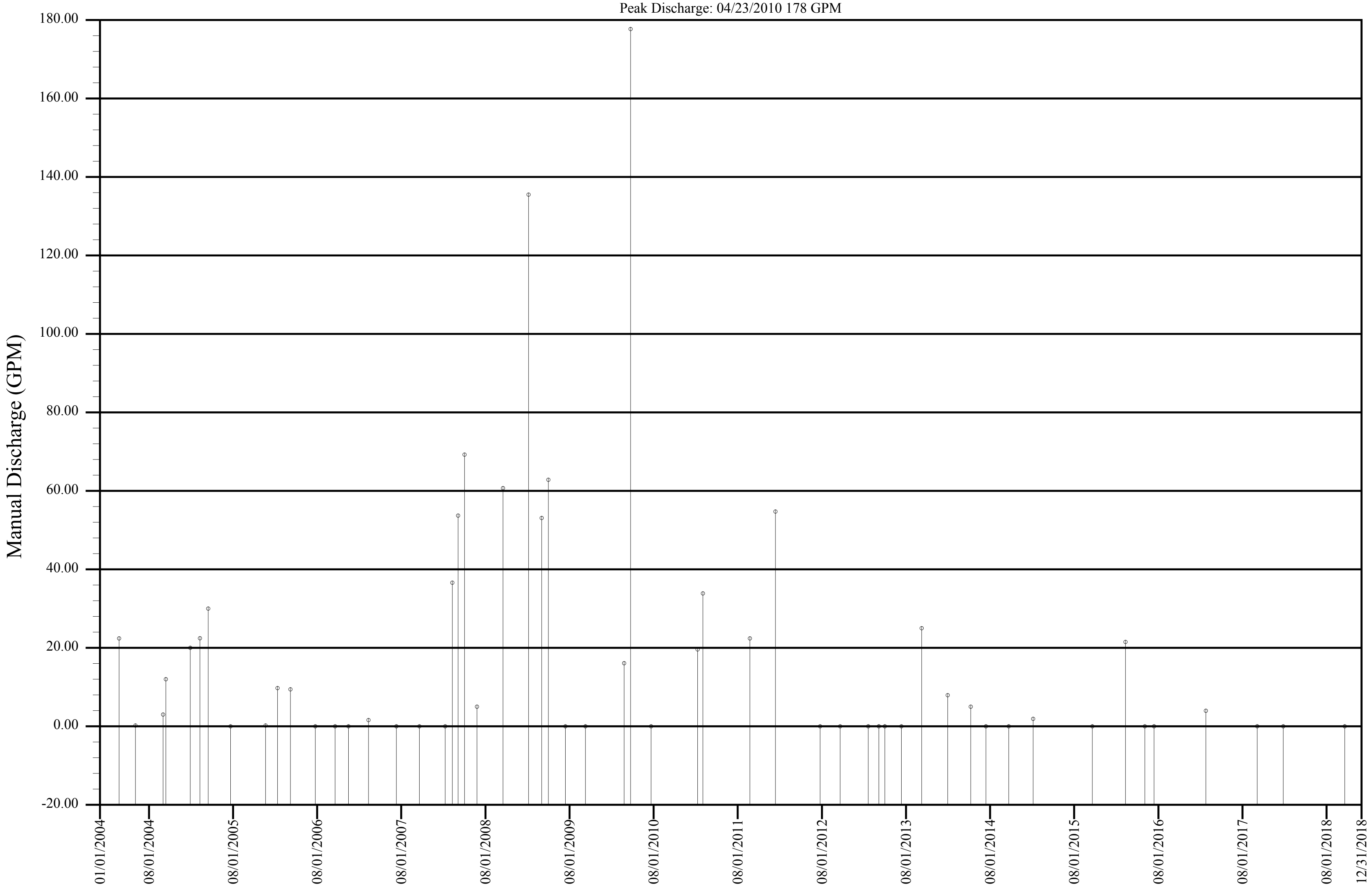
Analyte	Standard	No. Sites	Sites	Frequency	Exceedence Date Range	Exceedence Value Range	Exceedence Median
NAVAJO LIVESTOCK WATERING STANDARDS -- NNEPA (7/31/08)							
Arsenic, Total	0.00 - 200.00	0	none				
Boron, Dissolved	0.00 - 5000.00	0	none				
Cadmium, Total	0.00 - 50.00	0	none				
Chromium, Total	0.00 - 1000.00	0	none				
Copper, Dissolved	0.00 - 500.00	0	none				
Field Ph	6.50 - 9.00	0	none				
Lead, Total	0.00 - 100.00	0	none				
Nitrate Nitrogen_N	0.00 - 132.00	0	none				
NO3_NO2 Nitrogen_N	0.00 - 132.00	0	none				
Selenium, Total	0.00 - 50.00	0	none				
Total Recoverable As	0.00 - 200.00	0	none				
Total Recoverable Cd	0.00 - 50.00	0	none				
Total Recoverable Cr	0.00 - 1000.00	0	none				
Total Recoverable Pb	0.00 - 100.00	1	N14-F-P	0/0/7/17	09/15/00-01/13/06	(<)200.00 - 400.00	200.00
Total Recoverable Se	0.00 - 50.00	0	none				
Total Recoverable V	0.00 - 100.00	0	none				
Total Recoverable Zn	0.00 - 25.00	0	none				
Vanadium, Dissolved	0.00 - 100.00	0	none				
Vanadium, Total	0.00 - 100.00	0	none				
Zinc, Total	0.00 - 25.00	0	none				

Frequency = uncensored/between MDL&PQL/censored/no. samples, (B) = Between MDL&PQL range, (<) = Censored range

Figure 3.1

Sample Stage

Peak Discharge: 04/23/2010 178 GPM

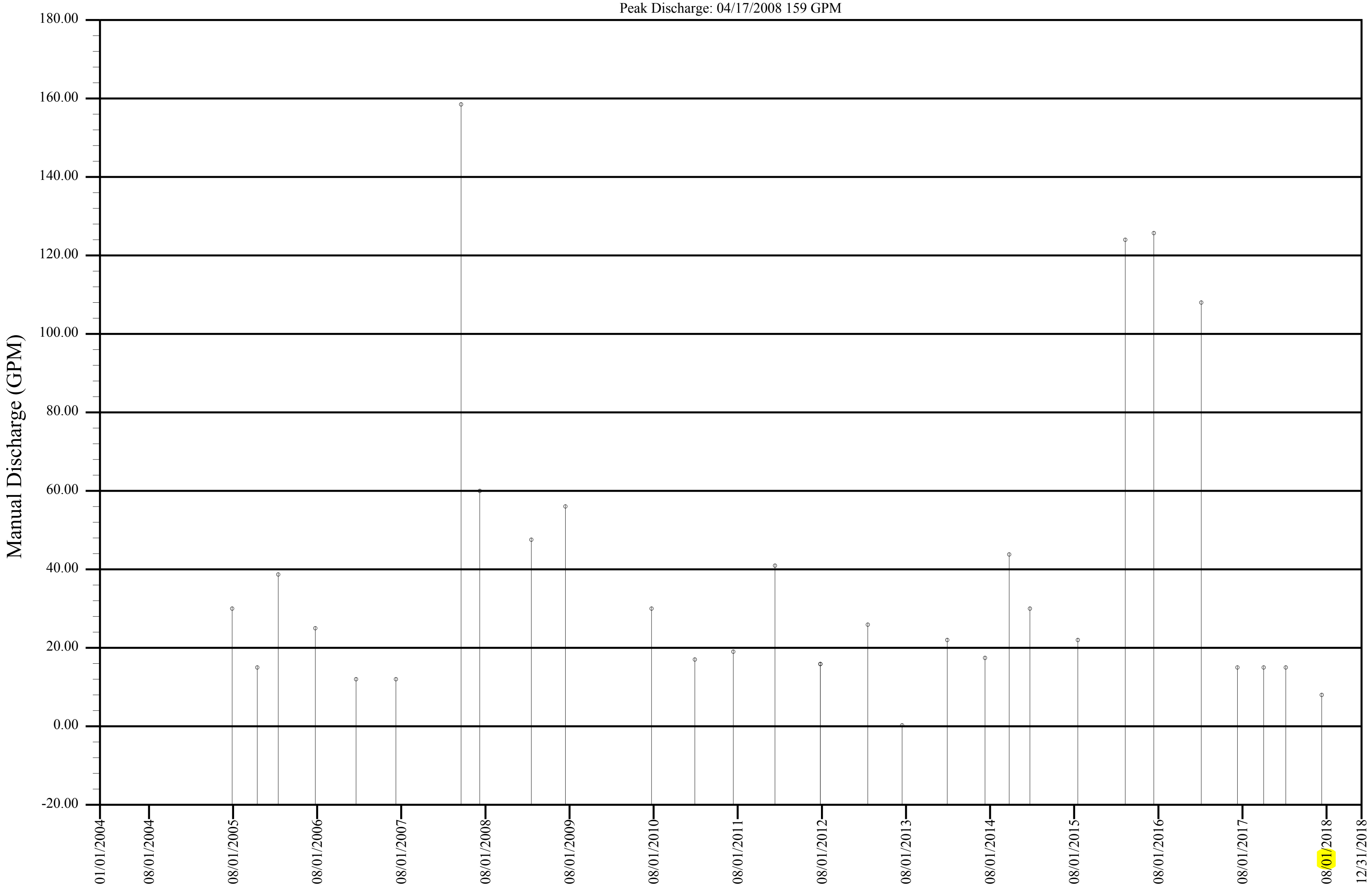


SW2A

Figure 3.2

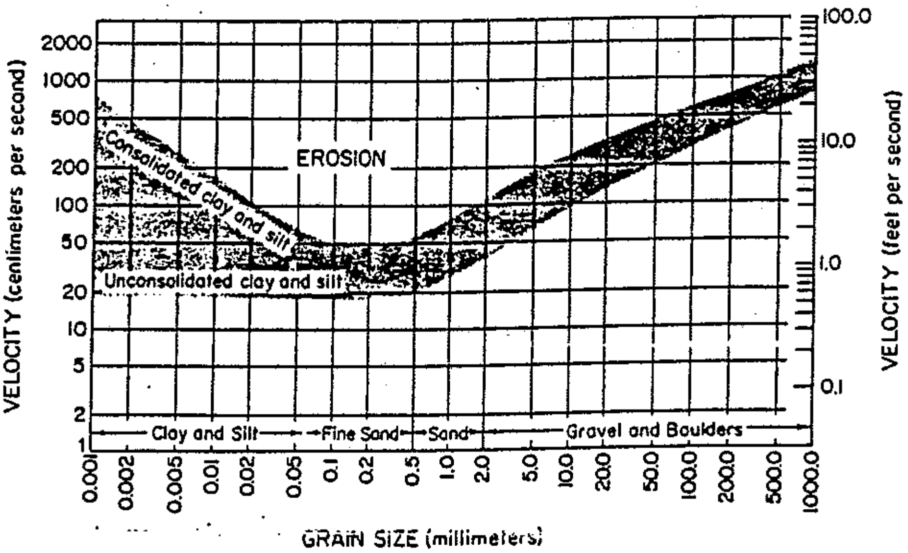
Sample Stage

Peak Discharge: 04/17/2008 159 GPM



SW80R

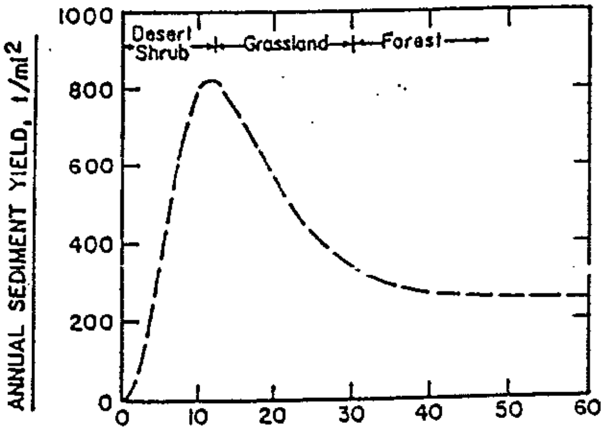
Figure 3.3



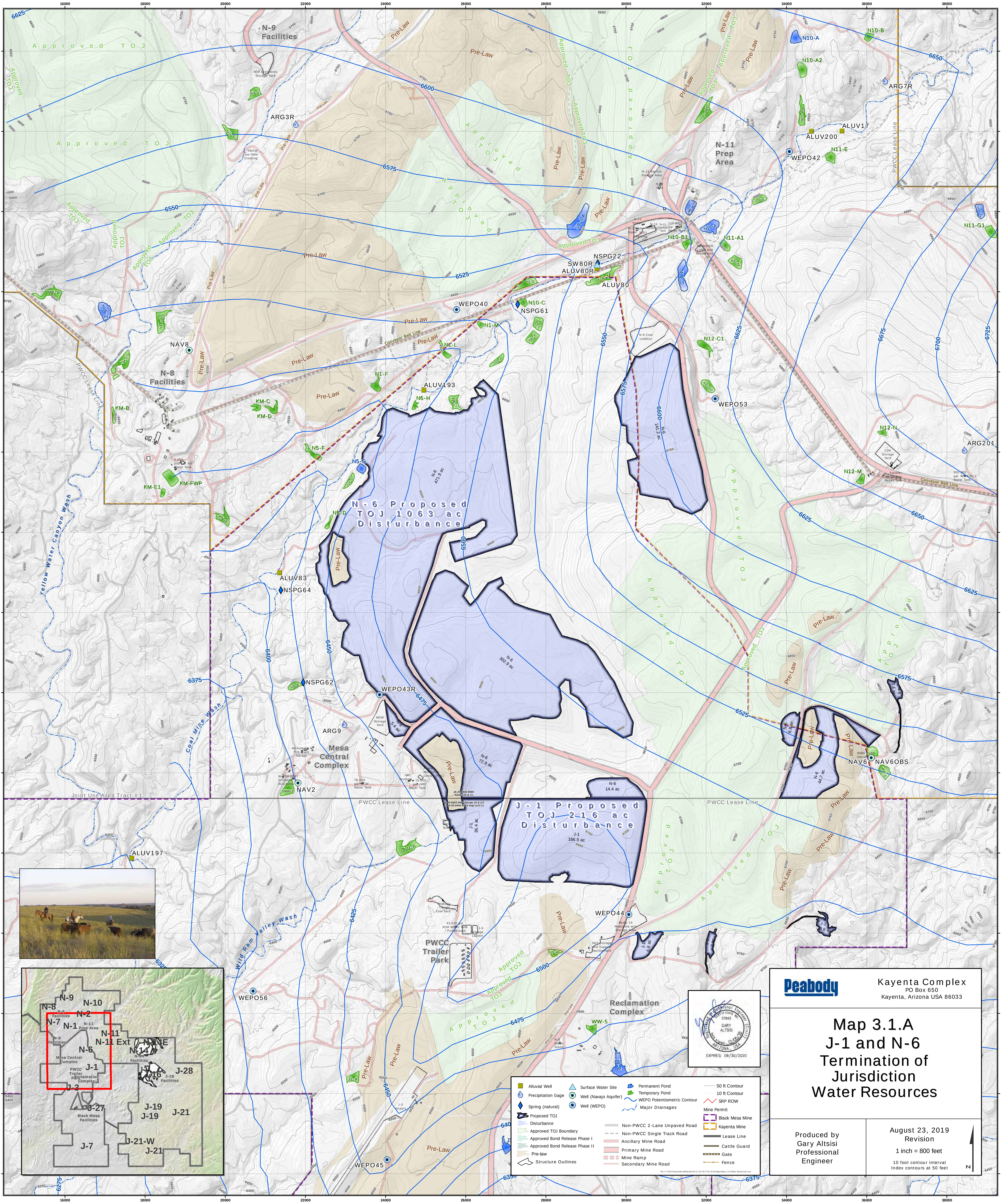
Hjulstrom's diagram, showing critical velocity for movement of quartz grains on a plane bed at a water depth of one meter, as modified by Sundborg (1956). The shaded area indicates the scatter of experimental data. There are very few reliable data in the clay and silt region.

(from Blatt, Middleton and Murray, 1972)

Figure 3.4



Variation of sediment yield with climate in the United States (from Langbein and Schumm, 1958).



File: F:\GIS\Projects\BondRelease\N6 J1 J16 N14 TOJ 2019\Maps\Map 3.1A Water Resources.mxd

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GARY ALTSISI
Date signed: 12/05/18
ARIZONA, USA
EXPIRES: 09/30/2020

Peabody

Kayenta Complex
PO Box 650
Kayenta, Arizona USA 86033

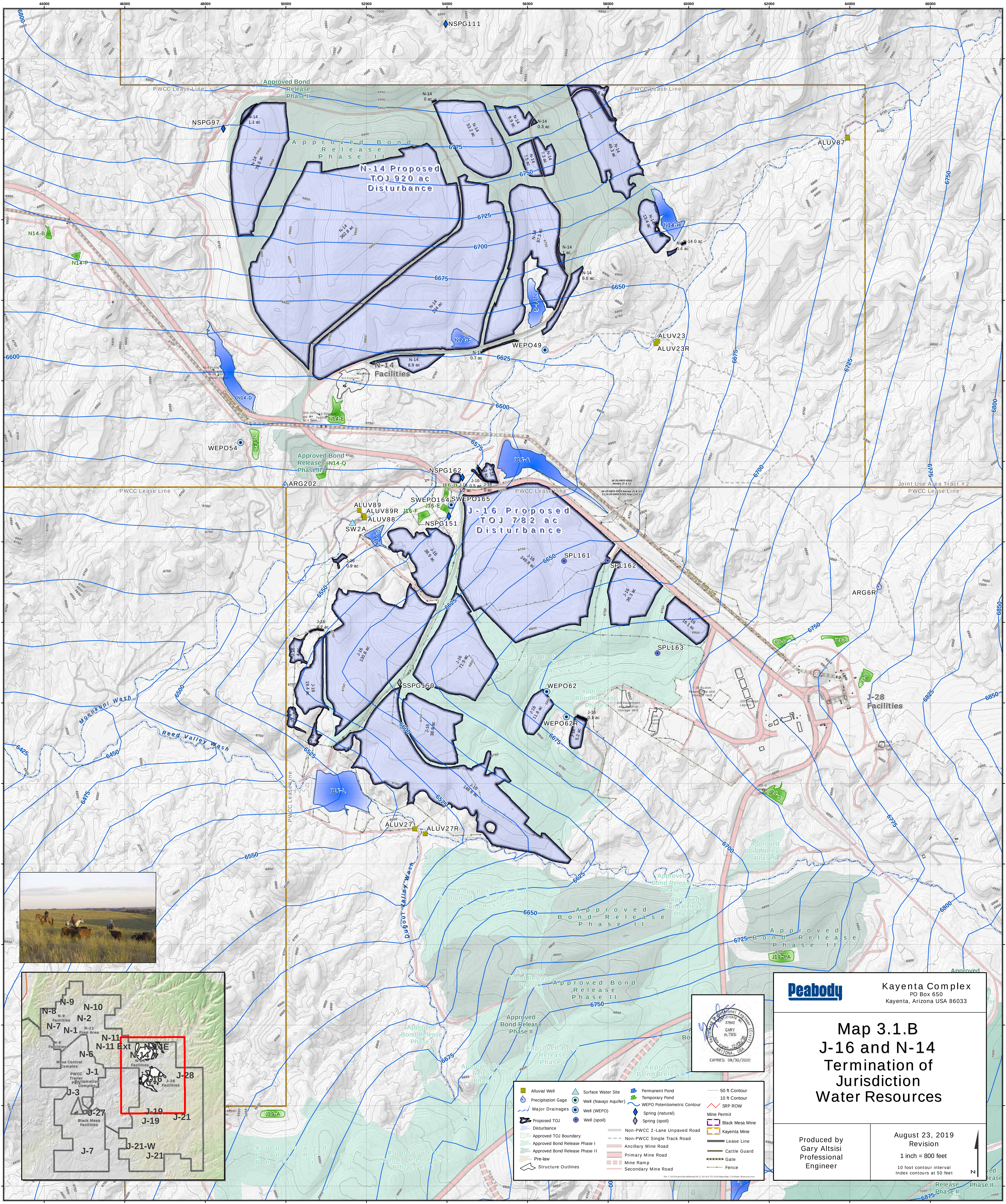
Map 3.1.A
J-1 and N-6
Termination of Jurisdiction
Water Resources

Produced by
Gary Altsisi
Professional
Engineer

August 23, 2019
Revision

1 inch = 800 feet

10 foot contour interval
Index contours at 50 feet



File: F:\GIS\Projects\BondRelease\N6 J1 J16 N14 TOJ 2019\Maps\Map 3.1B Water Resources.mxd

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Map 3.1.B
J-16 and N-14
Termination of Jurisdiction Water Resources

Produced by
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Professional
Engineer

August 23, 2019
Revision

1 inch = 800 feet

10 foot contour interval
Index contours at 50 feet

PEABODY WESTERN

Peabody Western Coal Company

February 24, 2020

Mr. Flynn Dickinson
Office of Surface Mining Reclamation & Enforcement
Program Support Division, Indian Programs Branch
One Federal Center, Building 41
Denver, CO 80225

RE: N6, J1, N14 & J16 TOJ Application, Peabody Western Coal Company (PWCC), Permit AZ-0001F, Pond N14-F Water Chemistry

Dear Mr. Dickinson:

Attached are recent water chemistry data collected at pond N14-F on April 4, 2019. Note that this is the only sample collected since 2006. Prior data for the period 1989—91 were collected immediately following reclamation of that portion of N14, while data for the period 2000-06 were collected per previous permit monitoring requirements (see Chapter 16, Table 10). This pond, along with ponds N14-D, N14-G and N14-H, are now on our internal list of ponds to be sampled semi-annually in preparation for bond release applications.

Along with water chemistry, an excursion report was generated for this site against Navajo Nation Surface Water Quality Standards for the Livestock Watering (LW) water use. No LW standards were exceeded for this sample.

With only one sample collected in recent years it is perhaps premature to make any projections concerning future water quality at this pond, however it does appear that chemically, pond N14-F poses no threat to livestock watering use.

Please let me know if you need additional data or have questions regarding any of the attached.

I may be reached at 928-677-5084 (Office), 480-408-1909 (Cell), or via email at johlman@peabodyenergy.com

Sincerely,

Jim Ohlman (PWCC)
Supervisor – Hydrology

Attachments:

Water Quality Data Report for Pond N14-F
Excursion Report for Pond N14-F, Livestock Watering Use

cc: Marie Shepherd (PWCC-KMC)
File

Water Quality Report
N14-F-P - PERM IMPOUND N14-F
01/01/2019-00:00 to 12/31/2020-23:59

Parameters	Units	04/04/2019 11:06
Field Parameters		
Field Ph	S.U.	7.9900
Temperature	C	12.5000
Conductivity	UMHOS/CM	361.0000
Field Salinity	0/00	0.2000
Laboratory Parameters		
Alk As CaCO3, Ph 4.5	MG/L	135.0000
Alk, Bicarb As CaCO3	MG/L	135.0000
Alk, Carb As CaCO3	MG/L	< 2.0000
Alk, Hydrox As CaCO3	MG/L	< 2.0000
Aluminum, Total	MG/L	1.0800
Aluminum, Dissolved	MG/L	B 0.0500
Arsenic, Total	UG/L	1.4000
Arsenic, Dissolved	UG/L	B 0.6000
Boron, Dissolved	UG/L	B 20.0000
Cadmium, Total	UG/L	< 0.0500
Cadmium, Dissolved	UG/L	< 0.0500
Calcium, Dissolved	MG/L	44.1000
Chloride	MG/L	14.4000
Chromium, Total	UG/L	< 10.0000
Chromium, Dissolved	UG/L	< 10.0000
Conductivity	UMHOS/CM	356.0000
Copper, Total	UG/L	< 10.0000
Copper, Dissolved	UG/L	< 0.8000
Fluoride	MG/L	B 0.2000
Hardness As CaCO3	MG/L	150.0000
Iron, Total	MG/L	1.2600
Iron, Dissolved	MG/L	0.0800
Lead, Total	UG/L	0.9000
Lead, Dissolved	UG/L	< 0.1000
Magnesium, Dissolved	MG/L	9.8000
Manganese, Total	MG/L	0.1200
Manganese, Dissolved	MG/L	0.0760
Mercury, Total	UG/L	< 0.2000
Nitrate Nitrogen_N	MG/L	< 0.0200
Nitrite Nitrogen_N	MG/L	< 0.0100
NO3_NO2 Nitrogen_N	MG/L	< 0.0200
Ph At 25 Deg. Cent.	UNITS	8.3000
Potassium, Dissolved	MG/L	10.9000
Selenium, Total	UG/L	< 1.0000
Silica, Dissolved	MG/L	5.1000
Sodium, Dissolved	MG/L	7.4000
Solids, Dissolved	MG/L	236.0000

"B" -- Between MDL and PQL, "<" -- Less than detection limit

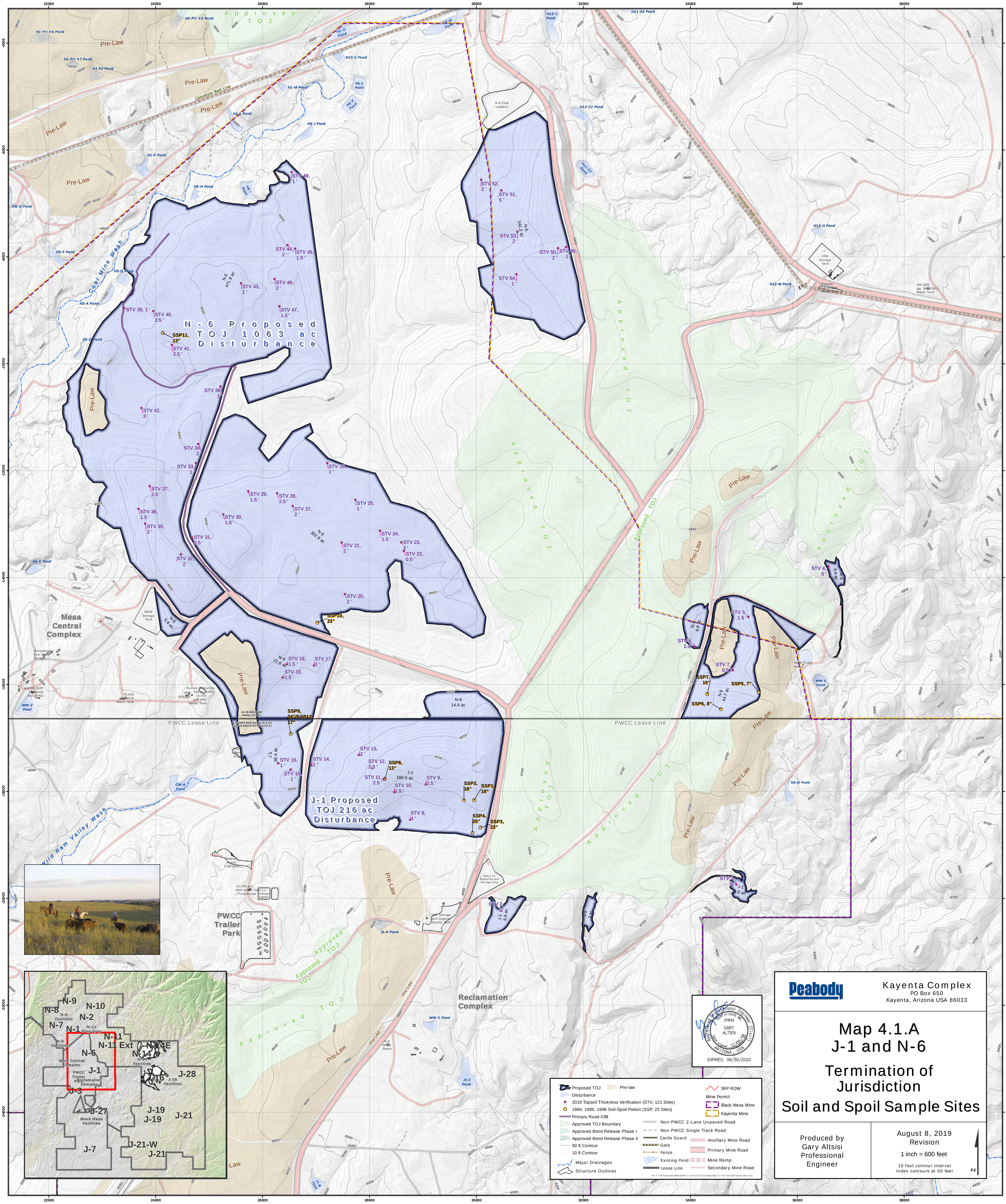
Water Quality Report
N14-F-P - PERM IMPOUND N14-F
01/01/2019-00:00 to 12/31/2020-23:59

Parameters	Units	04/04/2019 11:06
Laboratory Parameters		
Solids, Suspended	MG/L	B 10.0000
Sulfate	MG/L	47.4000
Vanadium, Total	UG/L	< 5.0000
Vanadium, Dissolved	UG/L	< 5.0000
Zinc, Total	MG/L	< 0.0100
Zinc, Dissolved	MG/L	< 0.0100
Chromium_3	UG/L	< 10.0000
Chromium_6	UG/L	< 5.0000
Bicarbonate As HCO3	MG/L	164.0000
Carbonate As CO3	MG/L	< 2.0000
Hydroxide As OH	MG/L	< 2.0000
Cation_Anion Balance	%	< -6.5000
SAR	%	0.2700
Solids, Diss. (Calc)	MG/L	223.0000
Sum Of Anions	MEQ/L	4.1000
Sum Of Cations	MEQ/L	3.6000
TDS Ratio	%	1.0600

"B" -- Between MDL and PQL, "<" -- Less than detection limit

```
                                                        ---- Excursion Summary Report ----

                                                                No.                                  Exceedence                Exceedence        Exceedence
                   Analyte                Standard             Sites        Sites      Frequency     Date Range               Value Range          Median
                   -------                --------             -----        -----      ---------     ----------               -----------        ----------

 NAVAJO LIVESTOCK WATERING STANDARDS -- NNEPA (1/14/13)

            Arsenic, Total        0.0000 -     200.0000           0         none

          Boron, Dissolved        0.0000 -    5000.0000           0         none

            Cadmium, Total        0.0000 -      50.0000           0         none

           Chromium, Total        0.0000 -    1000.0000           0         none

         Copper, Dissolved        0.0000 -     500.0000           0         none

                  Field Ph        6.5000 -       9.0000           0         none

               Lead, Total        0.0000 -     100.0000           0         none

        Nitrate Nitrogen_N        0.0000 -     132.0000           0         none

        NO3_NO2 Nitrogen_N        0.0000 -     132.0000           0         none

           Selenium, Total        0.0000 -      50.0000           0         none

      Total Recoverable As        0.0000 -     200.0000           0         none

      Total Recoverable Cd        0.0000 -      50.0000           0         none

      Total Recoverable Cr        0.0000 -    1000.0000           0         none

      Total Recoverable Pb        0.0000 -     100.0000           0         none

      Total Recoverable Se        0.0000 -      50.0000           0         none

       Total Recoverable V        0.0000 -     100.0000           0         none

      Total Recoverable Zn        0.0000 -      25.0000           0         none

       Vanadium, Dissolved        0.0000 -     100.0000           0         none

           Vanadium, Total        0.0000 -     100.0000           0         none

               Zinc, Total        0.0000 -      25.0000           0         none

Frequency = uncensored/between MDL&PQL/censored/no. samples, (B) = Between MDL&PQL range, (<) = Censored range
```

```
---- Water Use Summary Report ----

    Site                        NAVAJO

 N14-F-P
```



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Map 4.1.A
J-1 and N-6

Termination of Jurisdiction

Soil and Spoil Sample Sites

Produced by
Gary Altsisi
Professional
Engineer

August 8, 2019
Revision

1 inch = 600 feet

10 foot contour interval
Index contours at 50 feet

N

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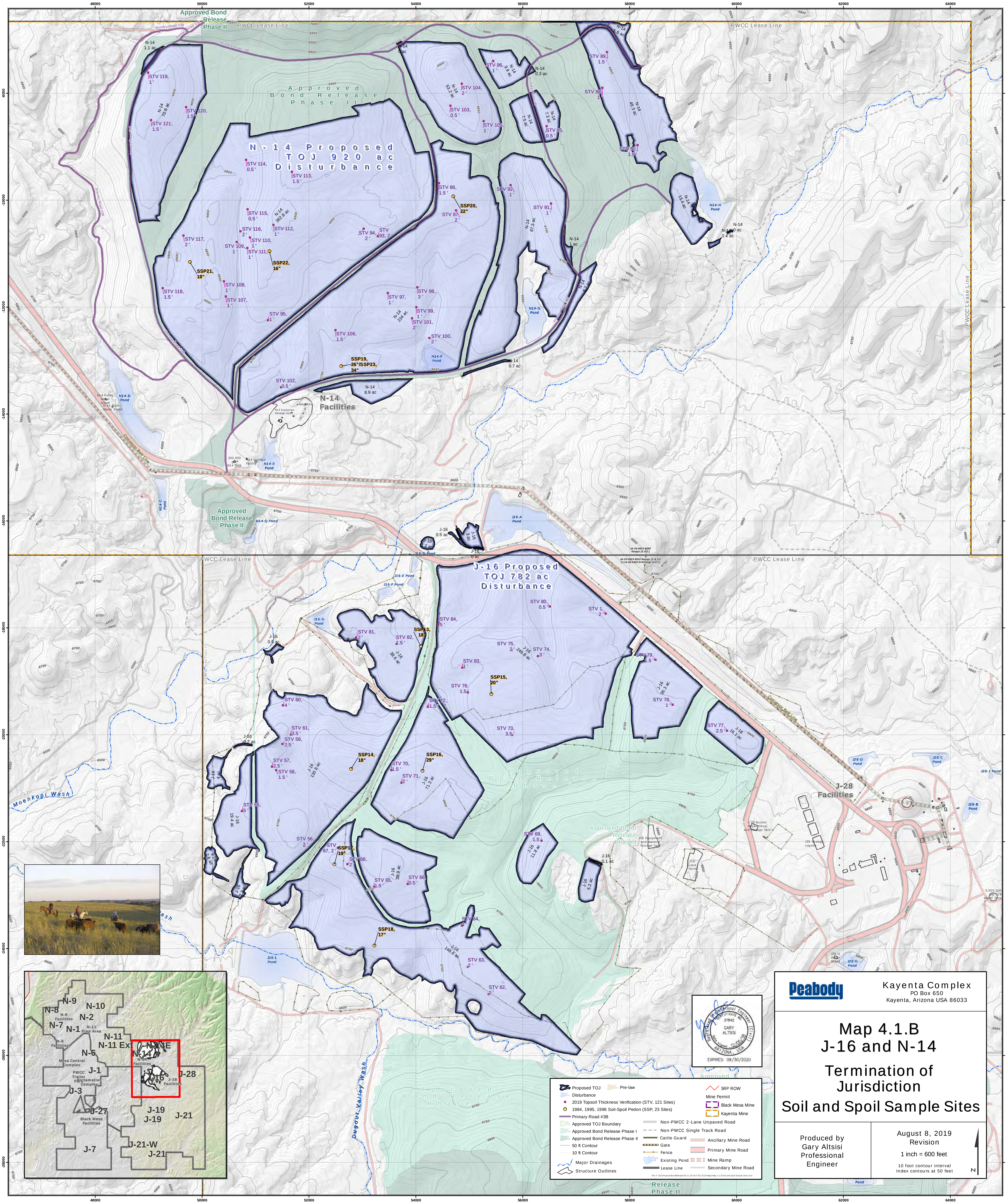
▨	Proposed TOJ
▨	Pre-law
▨	Disturbance
■	2019 Topsoil Thickness Verification (STV, 121 Sites)
●	1984, 1995, 1996 Soil-Spoil Pedon (SSP, 23 Sites)
▬	Primary Road #3B
▨	Approved TOJ Boundary
▨	Approved Bond Release Phase I
▨	Approved Bond Release Phase II
—	50 ft Contour
—	10 ft Contour
	Major Drainages
	Structure Outlines
	Non-PWCC 2-Lane Unpaved Road
	Non-PWCC Single Track Road
	Cattle Guard
	Gate
	Fence
	Existing Pond
▬	Lease Line
	Ancillary Mine Road
	Primary Mine Road
	Mine Ramp
	Secondary Mine Road
	SRP ROW
	Mine Permit
▭	Black Mesa Mine
▭	Kayenta Mine

File: F:\GIS\Projects\BondRelease\N6 J1 J16 N14 TOJ 2019\Maps\Map 4.1.A Soil and Spoil Sample Sites.mxd



Proposed TOJ
Pre-law
Disturbance
2019 Topsoil Thickness Verification (STV, 121 Sites)
1984, 1995, 1996 Soil-Spoil Pedon (SSP, 23 Sites)
Primary Road #3B
Approved TOJ Boundary
Approved Bond Release Phase I
Approved Bond Release Phase II
50 ft Contour
10 ft Contour
Major Drainages
Structure Outlines
Non-PWCC 2-Lane Unpaved Road
Non-PWCC Single Track Road
Cattle Guard
Gate
Fence
Existing Pond
Lease Line
SRP ROW
Mine Permit
Black Mesa Mine
Kayenta Mine
Ancillary Mine Road
Primary Mine Road
Mine Ramp
Secondary Mine Road

File: F:\GIS\Projects\BondRelease\N6 J1 J16 N14 TOJ 2019\Maps\Map 4.1.B Soil and Spoil Sample Sites.mxd

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Map 4.1.B
J-16 and N-14

Termination of Jurisdiction
Soil and Spoil Sample Sites

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Professional
Engineer

August 8, 2019
Revision

1 inch = 600 feet

10 foot contour interval
Index contours at 50 feet

N

Tab 4

Mine Soil Reconstruction

N-6, J-1, J-16, and N-14

Reclamation Liability Release Application

MINESOIL RECONSTRUCTION

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List of Maps

TAB 4

MINESOIL RECONSTRUCTION

N-6, J-1, J-16, and N-14

Introduction

For interim bond release areas, soil fertility, soil thickness, and soil-spoil quality data are typically collected and evaluated concurrently with postmine vegetation data to substantiate reclamation success and meet regulatory requirements. The soil and spoil data are used for determining the potential productivity of a reclaimed site and indicating whether a plant growth medium can support the postmine land use. Postmine soil pits are often used to evaluate plant rooting characteristics and to compare soil-spoil profile data with site-specific revegetation data and premine soil types and characteristics. The following sections present the soil and spoil monitoring data for the N-6, J-1, J-16, and N-14 interim reclamation liability release areas (RLRA’s). This information addresses the regulatory requirements at 30 CFR 715, Subchapter B, the applicable subjects in the Office of Surface Mining Reclamation and Enforcement (OSMRE) checklist for interim lands release applications, and OSM's Guidance for Initial Program Termination of SMCRA Jurisdiction (OSMRE, July 1997).

Pedon Sampling Method

In 1984, a postmine soil-spoil pedon (SSP) study was performed at the Kayenta Complex (KC) to describe soil and spoil characteristics, evaluate plant performance, and review overall reclamation success in areas that had been reclaimed for 5 to 12 years. The permanent vegetation has generally established sufficiently after three to four years to evaluate interactions between rooting characteristics and soil/spoil quality (Schafer et al. 1979). Mr. Jim Nyenhuis, Certified Professional Soil Scientist (ARCPACS 2753), described and sampled 112 pedons in seven separate reclamation areas. Seven pedons were in the J-1 and N-6 RLRA. The J-1 and N-6 sites are listed in Table 4.2.A shown on Exhibit 4.1.A.

The final phases of the SSP and plant sampling study at the KC were conducted during Fall 1995 and Spring 1996. This program involved collection of collocated soil, spoil, and plant samples from all existing reclamation areas of the KC. A certified professional soil scientist (Jim Nyenhuis) described and sampled 108 pedons in 10 separate reclamation areas. Study sites were selected from previously located random vegetation monitoring sites. The 16 SSPs located in the N-6, J-1, J-16, and N-14 areas are listed in Tables 4.2.A, 4.2.B, and 4.2.C and shown on Maps 4.1.A and 4.1.B.

Soil pits were excavated with a backhoe to a depth of 48 to 80 inches to expose all soil and upper spoil horizons. These horizons were identified and differentiated by color, texture, root density, consistence, structure, reaction, and rock fragment content. The individual horizons were described and separately sampled. Spoil material was described and sampled to profile depths that exceeded the plant rooting zone that ranged from 26 to 80 inches. The methodology used to prepare the pedon descriptions followed standard techniques and procedures of the National Cooperative Soil Survey as outlined in USDA-SCS (1951), USDA-SCS (1975), USDA-SCS (1981), Fosberg and Falen (1983), and USDA-SCS (1971). Sampling conducted in 1995 and 1996 also followed the protocol of Spackman et al., 1994.

The soil and spoil material were placed in clean, labeled, 4-mil thick polyethylene storage bags and were kept cool and dry to limit chemical changes. The samples collected during 1984 were shipped to Peabody Central Laboratory in Freeburg, Illinois for analysis. Laboratory analyses for the samples collected during 1995 and 1996 were completed by Inter-Mountain Lab, Farmington, New Mexico. The soil analysis methods are listed in Table 4.1. Available water-holding capacity (AWHC) was determined by using methods described by SCS (1978), Olson (1981), Flint and Childs (1984), and the Soils Committee (1984). The AWHC was determined for the 60-inch soil-spoil pedon as recommended by the literature even though rooting depths extended past this limit in 45 percent of the profiles.

Field and laboratory results for soil and spoil samples collected from the N-6, J-1, J-16, and N-14 interim release area sites are presented in Tables 4.2.A, 4.2.B, 4.2.C, 4.3.A, 4.3.B, 4.3.C, and 4.4. The results are discussed in the following sections titled soil thickness, soil quality, spoil quality, minesoil genesis, and soil fertility. Field description data are on file at Peabody Western Coal Company's (PWCC) Kayenta Mine N-8 Operations office and the Southwest Operations office in Flagstaff.

Soil Thickness

Soil was redistributed from stockpiles or replaced directly from soil removal areas in a minimum uniform thickness of more than six inches prior to contour disking. Pursuant to

Permit AZ-0001, soil replacement thickness was required to be six inches (0.5 feet) or greater.

Soil thickness was measured as part of the soil-spoil pedon sampling that was conducted during 1984, 1995, and 1996. Twenty-three pedons were sampled during these periods, and the soil thickness values are presented in Tables 4.2.A, 4.2.B, and 4.2.C. The 23 sample sites were selected systematically based on topographic, vegetative quality, and inferred soil replacement differences. Soil thickness among these 23 profiles ranges from 7 to 34 inches, with a mean of 17 inches for the J-1 and N-6 reclaimed area, 20 inches for J-16, and 23 inches for N-14.

PWCC completed a final soil depth survey of the N-6, J-1, J-16, and N-14 reclaimed areas during spring 2019. During April and May 2019, personnel from Peabody (PWCC), observed sites in the N-6, J-1, J-16, and N-14 reclaimed areas for a final verification of soil replacement thickness within each area.

A stratified grid sampling scheme using a random number generator program was used for the PWCC survey to locate 121 sites prior to going into the field. A Tremble GeoXT survey grade GPS unit was used to navigate to each of the sites. A sampling density of about 1 site per 25 acres (121 sites over 2,981 acres) was used being similar to the density used and approved previously at the Kayenta Complex for the N-1/N-2, N-6, N-7/N-8, N-14, J-1, J-3, J-7, J-16, J-19, and J-21 soil thickness evaluations (PWCC, 2000; PWCC, 2001; PWCC, 2007; PWCC, 2009; PWCC, 2011; PWCC, 2013; PWCC, 2015; PWCC, 2016; PWCC, 2017).

During the final soil depth survey, a 3 1/2-inch bucket auger was used at all sites to verify the soil thickness by augering to the contact with spoil. Soil thickness values were recorded to the nearest 0.5 foot. Soil thickness among the 121 profiles ranged from 0.5 to 5.0 feet among the RLRAs, with a mean of 1.8 feet. The results of the soil thickness verification (STV) survey are shown in Tables 4.5.A, 4.5.B, and 4.5.C. Maps 4.1.A and 4.1.B show the location of all STV sites and their respective soil thickness.

The field surveys of the soil replacement thickness in the N-6, J-1, J-16, and N-14 reclaimed areas show the areas follow the approved reclamation plan in Permit AZ-0001 and the initial program at 30 CFR 715.16 (Topsoil Handling). Field survey results confirm greater than six inches (0.5 foot) of soil were replaced in these RLRAs.

Soil Quality

Soil textures at the 23 SSP sites were typically 65% sandy loam and 35% sandy clay loam among the N-6, J-1, J-16, and N-14 areas. Fine and very fine sand were dominant among the sand soil separate. Spoil textures were predominantly gravelly to very gravelly sandy clay loam and clay loam. Total rooting depths ranged from 26 to 80 inches, with a mean of 55 inches (Tables 4.2.A, 4.2.B, 4.2.C, 4.3.A, 4.3.B, and 4.3.C). The major rooting zone, where 80 percent of the roots were identified, ranges from 10 to 39 inches, with a mean of 22 inches. These mean rooting depths are normal for grasslands based on information from Dollhopf et al (1985) and Holechek (1982) which indicate 90 to 95 percent of the total below ground root biomass occurs in the upper 18 to 24 inches of reclaimed and native range profiles. The available water holding capacity (AWHC) ranged from 5.1 to 7.5 inches, with mean values of 6.2, 6.8, and 6.1 inches per 60-inch soil-spoil profile for the N-6/J-1, J-16, and N-14 RLRAs, respectively (Tables 4.2.A, 4.2.B, and 4.2.C). These mean AWHC values are in the fair or medium category (Schafer, 1979).

The physical and chemical properties of all soil horizons, listed in Tables 4.3.A, 4.3.B, and 4.3.C, were compared to suitability values specified in Table 4.6. The values given in Table 4.6, extracted from approved Kayenta Mine Permit AZ-0001F, Volume 11A, Appendix A, Table 11 (PWCC, 2017) were used in this comparison since no guidance was made available by OSMRE for use in identifying suitable soil when the subject lands were reclaimed. The soil from all sites had suitable values for all parameters.

Spoil Quality

The physical and chemical properties of all spoil horizons, listed in Tables 4.3.A, 4.3.B, and 4.3.C, were compared to suitability values specified in Table 4.7. The values given in Table 4.7, extracted from approved Kayenta Mine Permit AZ-0001F, Chapter 22, Table 11 (PWCC, 2017) were used in this comparison since no guidance was made available by OSMRE for use in identifying potentially toxic- or acid-forming materials when the subject lands were reclaimed. The spoil had suitable values for all parameters except for the 3 pH values at J-1/N-6, 2 pH values at J-16, 1 pH value at N-14, and 1 EC value at N-14 as designated in Tables 4.3.A, 4.3.B, and 4.3.C. Further review of the field pedon descriptions for these six soil-spoil pedon sites indicated these "unsuitable" values were suitable for plant growth since fine and very fine roots occurred within and often extended through each of these horizons.

Minesoil Genesis

Soil formation processes that are evident in the reclaimed soil-spoil pedons in the N-6, J-1, J-16, and N-14 areas combined include formation of organic acids near the surface and structure formation. Mean pH values in the upper 5.2 inches are 0.24 units lower compared to the underlying soil increments (Tables 4.3.A and 4.3.C). The mean pH of the surface and underlying soil horizons was 7.83 and 8.07, respectively. Although the two mean values are not statistically different, the pH values in the surface were less than the adjacent lower horizon pH values for 100 percent of the profiles.

Structure formation has occurred in the upper 4 to 22 inches of the topsoiled spoil pedons (Tables 4.2.A, 4.2.B, and 4.2.C). Structure formed to a mean depth of 11.1 inches in the 23 pedons that were observed. The most common structure descriptions were moderate medium to coarse subangular blocky, moderate medium to coarse granular, and moderate medium to coarse platy. The grade, type, and size of structure did not appear to be dependent upon soil texture that included predominantly sandy loams and sandy clay loams.

Similar structure formation and organic acid accumulation occurred in the recent and old soil-spoil pedons sampled by Schafer et al. (1979 and 1980) in August 1976 at Colstrip, Montana, and in 5- to 12-year-old soil-spoil pedons in the N-1, N-2, N-6, N-7, N-8, J-1, J-3, and J-7 areas of the KC (PWCC, 2000; PWCC, 2001; PWCC, 2013). Weak grades of structure developed in the upper four inches of recently (two to seven years) reclaimed loamy sand and sandy loam topsoil and spoil. Moderate grades of structure developed in the upper 11 inches of 50-year-old reclaimed loamy sand spoil. Organic acids in the upper 20 inches of the 50-year-old pedons have soil reaction levels 0.6 units (pH = 7.7) below those at depths greater than 20 inches (pH = 8.3). Soil reaction differences in some of the recently reclaimed pedons were only 0.3 units lower in the upper 4 inches compared to the 4- to 8-inch increment. The reaction and structure data from the N-6, J-1, J-16, and N-14 RLRAs show initial stages of soil formation have occurred and compare closely with existing documented research.

Soil Fertility

Fertility data for surface soil samples from the J-1 and N-6 areas sampled in 1984 is presented in Table 4.4. Fertilizer levels considered adequate to obtain good plant establishment, site suitability, floristic diversity, and moderate productivity are listed in Table 4.8. These fertility levels are recommended for native and improved range grasses.

The J-1 and N-6 soil has a high to excellent fertility status for potassium, a predominantly moderate to high status for pH, texture, phosphorous, and organic matter, and low to moderate status for nitrogen. A nitrogen fertilizer application is not recommended because organic matter levels are acceptable for southwestern semiarid soils.

Conclusion

Soil-spoil pedon description data from the N-6, J-1, J-16, and N-14 RLRAs show rooting characteristics and soil genesis are normal compared to native undisturbed and older reclaimed landscapes. Soil thickness and fertility (productivity) are adequate for sustaining the established vegetation community and postmine land use. Nitrogen levels are low; however, no additional fertilizer is recommended because of potential weed infestation concerns, sampling was of limited extent, and since vegetation cover has met the desired standard (see Tab 5). The mean soil thickness of 1.8 feet (representing 144 sample sites) exceeded minimum requirements presented in the approved reclamation plan in Permit AZ-0001. Soil and spoil quality are suitable over the entire RLRA as indicated by plant rooting depths, lab analysis, and vegetation cover data (see Tab 5).

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TABLE 4.1

Parameter, Procedure, and Reference List
Peabody Central Laboratory
Freeburg, Illinois.

Parameter-Units	Procedure-Reference
Sample preparation [1]	Samples were dried at less than 35°C and crushed to pass a 10-mesh sieve (excessive grinding was avoided).
Subsampling less than 2mm fraction [1]	U.S. Salinity Lab (1969), Method 1, p. 83-84.
Preparation of saturation extract	Rhoades (1982), Method 10-2.3.1
pH (determination using saturated paste) [1]	U.S. Salinity Lab (1969), Method 21a, p. 102
Conductivity of saturation extract in mmhos/cm at 25°C [1]	Rhoades (1982), Method 10-3.3
Acid base potential (ABP) in tons $CaCO_3$ per 1,000 tons of soil or spoil	Sobek et al. (1978), p. 51-55; U.S. Salinity Lab (1969), Method 23c, p. 105; and Smith et al. (1974), p. 48-49. 60-mesh sieve.
Sodium Adsorption Ratio [1]	Rhoades (1982), Section 10-3.4, U.S. Salinity Lab (1969), p. 26
Organic matter in percent	Nelson & Sommers (1982), Section 29-3.5.3
Particle size analysis in % sand, silt, and clay [1]	Bouyoucos (1962)
Textural classification [1]	USDA-SCS (1951), p. 209
Ammonium & Nitrate (total) Nitrogen in ppm	Keeney & Nelson (1982), Methods 33-6.2 & 33-6.3 or 33-7 & 33-8
Phosphorus in ppm	Olsen & Sommers (1982), Methods 24-5.4
Potassium in ppm	Knudsen, et al. (1982), Method 13-3.3
Selenium, total in ppm	Kubota & Cary (1982), Method 27-5.
Boron in ppm	Bingham (1982), Method 25-9.1

[1] Similar procedures and references were used by Inter-Mountain Lab, Farmington, New Mexico for analyzing these parameters in 1995 and 1996.

TABLE 4.2.A

Location(1) and Field Description Data for Soil-Spoil Pedon (SSP) Samples Collected from J-1 and N-6.

Site ID	Sample Date	Easting(2) (Feet)	Northing(2) (Feet)	Soil Thickness (Inches)	Rooting(3) Depth (Inches)	Rock Fragments Soil-Spoil (%)(4)	AWHC(5) (Inches - Class)	Structure Formation (Inches)
SSP1	1984	29,955	-18,165	19	30 (19)	NR-50	6.1-M	15
SSP2	1984	29,765	-18,170	18	38 (24)	NR-50	5.4-L	11
SSP3	1984	30,075	-18,675	23	51 (29)	NR-50	6.0-M	10
SSP4	1984	29,925	-18,775	25	34 (34)	NR-50	6.2-M	8
SSP5	1984	35,280	-16,145	7	48 (16)	NR-35	6.2-M	7
SSP6	1984	34,575	-16,465	8	32 (26)	NR-50	5.1-L	8
SSP7	1984	34,320	-16,180	10	40 (10)	NR-NR	5.1-L	10
SSP8	1995	28,286	-17,768	13	80 (18)	5-42	6.4-M	4
SSP9	1995	26,525	-16,925	24	50 (24)	6-40	7.3-M	15
SSP10	1995	27,024	-14,845	23	69 (23)	10-45	7.4-M	15
SSP11	1995	24,129	-9,426	13	50 (20)	15-44	6.1-M	8
SSP12	1996	26,525	-16,925	17	78 (17)	15-36	7.4-M	17
MEAN	**---**	**---**	**---**	**17**	**50 (22)**	**10-45**	**6.2-M**	**11**

(1) For location, see Map 4.1.A.

(2) PWCC coordinate system.

(3) The major rooting zone, i.e. where 80 percent of roots are identified, is listed in parenthesis.

(4) NR – Data not recorded.

(5) AWHC - Available water holding capacity, classes include L - low and M - medium.

TABLE 4.2.B*

Location(1) and Field Description Data

For Soil-Spoil Pedon (SSP) Samples Collected from J-16.

Site ID	Sample Date	Easting(2) (Feet)	Northing(2) (Feet)	Soil Thickness (Inches)	Rooting(3) Depth (Inches)	Rock Fragments Soil-Spoil (%)	AWHC(4) (Inches - Class)	Structure Formation (Inches)
SSP13	1995	54,091	-18,344	18	36 (18)	3-55	5.7-L	5
SSP14	1995	52,789	-20,638	18	68 (18)	20-40	6.9-M	5
SSP15	1995	55,410	-19,240	20	70 (20)	6-50	7.3-M	20
SSP16	1995	54,125	-20,675	29	75 (29)	10-45	7.5-M	8
SSP17	1995	52,475	-22,425	19	71 (39)	5-38	6.7-M	5
SSP18	1995	53,225	-23,944	17	72 (17)	3-37	6.9-M	6
MEAN	**---**	**---**	**---**	**20**	**65 (24)**	**8-44**	**6.8-M**	**8**

*Footnotes for Table 4.2.B shown below as listed for Table 4.2.C.

TABLE 4.2.C

Location(1) and Field Description Data

For Soil-Spoil Pedon (SSP) Samples Collected from N-14.

Site ID	Sample Date	Easting(2) (Feet)	Northing(2) (Feet)	Soil Thickness (Inches)	Rooting(3) Depth (Inches)	Rock Fragments Soil-Spoil (%)	AWHC(4) (Inches - Class)	Structure Formation (Inches)
SSP19	1995	52,605	-13,104	26	26 (11)	3-65	5.2-L	11
SSP20	1995	54,700	-9,930	22	72 (22)	5-42	7.2-M	22
SSP21	1995	49,772	-11,155	18	72 (20)	3-47	5.7-L	18
SSP22	1995	51,258	-10,958	16	72 (28)	5-48	5.9-L	16
SSP23	1996	52,605	-13,104	34	34 (11)	5-70	6.3-M	11
MEAN	**---**	**---**	**---**	**23**	**55 (18)**	**4-54**	**6.1-M**	**16**

(1) For location, see Map 4.1.B.

(2) PWCC coordinate system.

(3) The major rooting zone, i.e. where 80 percent of roots are identified, is listed in parenthesis.

(4) AWHC - Available water holding capacity, classes include L – low and M - medium.

TABLE 4.3.A

Soil-Spoil Pedon (SSP) Analytical Data for Sites Located Within J-1 and N-6.

Sample Location	Sample Medium	Sample Depth (Inches)	Sample Thickness (Inches)	pH	EC (mmho/cm)	ABP **	SAR	Sand (%)	Silt (%)	Clay (%)	Texture ***
SSP1	soil	0	4	8.1	0.5	77	0.6	78	7	15	SL
SSP1	soil	4	11	8.4	0.6	152	1.6	64	12	24	SCL
SSP1	soil	15	4	8.2	0.9	119	1.9	68	14	18	SL
SSP1	spoil	19	6	8.0	3.5	77	1.5	48	25	27	SCL
SSP1	spoil	25	12	7.9	4.4	74	1.8	44	26	30	CL
SSP1	spoil	37	11	7.9	4.4	105	1.4	43	27	30	CL
SSP2	soil	0	3	8.0	0.4	105	0.3	51	19	30	SCL
SSP2	soil	3	2	8.2	0.4	61	0.8	59	17	24	SCL
SSP2	soil	5	6	8.3	0.4	77	2.0	57	17	26	SCL
SSP2	soil	11	7	8.2	0.4	38	1.9	67	16	17	SL
SSP2	spoil	18	6	8.1	1.4	50	1.7	68	14	18	SL
SSP2	spoil	24	14	7.9	5.2	50	2.2	70	14	16	SL
SSP2	spoil	38	12	8.1	2.7	69	2.2	68	16	16	SL
SSP3	soil	0	4	7.9	0.5	57	0.2	71	13	16	SL
SSP3	soil	4	6	8.3	0.4	69	1.8	73	12	15	SL
SSP3	soil	10	13	8.6	0.6	59	7.9	72	14	14	SL
SSP3	spoil	23	6	7.8	5.2	59	3.8	48	24	28	SCL
SSP3	spoil	29	12	7.9	5.5	56	3.6	48	24	28	SCL
SSP3	spoil	41	10	7.8	5.7	67	2.4	56	18	26	SCL
SSP4	soil	0	4	7.9	0.5	52	0.7	64	15	21	SCL
SSP4	soil	4	5	8.1	0.5	47	1.4	64	14	22	SCL
SSP4	soil	9	6	8.2	0.6	40	3.6	65	12	23	SCL
SSP4	soil	15	10	8.3	0.6	58	3.0	66	13	21	SCL
SSP4	spoil	25	6	8.0	3.1	90	2.7	55	18	27	SCL
SSP4	spoil	31	16	8.0	2.5	94	1.7	51	19	30	SCL
SSP4	spoil	47	5	7.9	3.1	69	2.6	55	15	30	SCL
SSP5	soil	0	3	7.8	1.1	24	1.1	56	22	22	SCL
SSP5	soil	3	4	7.9	0.8	24	1.0	55	22	23	SCL
SSP5	spoil	7	6	6.2	4.4	N/A	1.3	42	28	30	CL
SSP5	spoil	13	12	**5.2***	5.0	N/A	1.5	39	28	33	CL
SSP5	spoil	25	23	5.8	5.1	N/A	2.8	42	26	32	CL
SSP6	soil	0	3	7.9	0.6	23	0.9	54	23	23	SCL
SSP6	soil	3	5	8.0	0.5	21	1.5	54	26	20	SL
SSP6	spoil	8	6	**5.4***	3.4	N/A	1.6	46	28	26	SCL
SSP6	spoil	14	12	**5.2***	3.7	N/A	2.3	43	28	29	CL
SSP6	spoil	26	12	5.7	3.4	N/A	1.6	48	26	26	SCL
SSP6	spoil	38	10	5.1	3.3	N/A	1.4	54	23	23	SCL
SSP7	soil	0	4	7.8	0.8	22	0.9	63	18	19	SL
SSP7	soil	4	6	8.0	1.2	21	3.1	68	14	18	SL
SSP7	spoil	10	6	5.8	4.7	N/A	0.6	49	24	27	SCL
SSP7	spoil	16	12	7.2	6.0	1	5.4	54	25	21	SCL
SSP7	spoil	28	12	7.3	6.9	6	7.8	59	23	18	SL
SSP7	spoil	40	12	6.8	7.8	N/A	9.8	55	22	23	SCL
SSP8	soil	0	13	7.6	0.5	21	0.5	65	17	18	SL
SSP8	spoil	13	67	6.7	5.6	11	5.4	36	31	33	CL
SSP9	soil	0	24	7.9	0.6	31	1.6	64	19	17	SL
SSP9	spoil	24	54	7.8	6.1	49	3.6	34	34	32	CL
SSP10	soil	0	23	7.9	1.3	43	2.9	52	26	22	SCL
SSP10	spoil	23	46	7.6	8.5	15	27.2	30	38	32	CL
SSP11	soil	0	13	7.9	0.5	42	0.7	64	18	18	SL
SSP11	spoil	13	17	7.9	0.7	114	2.4	34	38	28	CL
SSP11	spoil	30	40	7.5	8.4	28	16.0	34	31	35	CL
SSP12	soil	0	17	7.6	0.6	40	0.8	51	30	19	L
SSP12	spoil	17	21	7.5	4.3	47	3.2	41	35	24	L
SSP12	spoil	38	40	7.7	4.6	82	6.4	26	42	32	CL

* Increments shaded in bold and identified to be "unsuitable" based on soil chemistry analysis.

** Units are tons calcium carbonate per 1000 tons of material. N/A code used where sulfur fractionation was not completed. Values listed are based on total sulfur percentage.

*** Soil texture presented for fine earth fraction of sample only. SL - sandy loam, L - loam, SCL - sandy clay loam, and CL - clay loam.

TABLE 4.3.B.
Soil-Spoil Pedon (SSP) Analytical Data for Sites Located Within J-16.

Sample Location	Sample Medium	Sample Depth (Inches)	Sample Thickness (Inches)	pH	EC (mmho/cm)	ABP **	SAR	Sand (%)	Silt (%)	Clay (%)	Texture ***
SSP13	soil	0	18	7.7	0.9	33	2.2	50	31	19	SCL
SSP13	spoil	18	18	7.5	8.6	1	6.5	18	38	44	C
SSP13	spoil	36	26	7.7	6.6	43	3.9	67	14	19	SL
SSP14	soil	0	18	7.3	3.4	11	0.9	55	25	20	SL
SSP14	spoil	18	50	**4.1***	8.5	4 (P)	8.2	37	35	28	CL
SSP15	soil	0	20	7.5	3.1	20	0.9	55	25	20	SL
SSP15	spoil	20	50	**5.4***	7.8	4 (P)	7.9	24	37	39	CL
SSP16	soil	0	29	7.5	1.0	14	0.9	61	21	18	SL
SSP16	spoil	29	46	6.7	9.4	12 (P)	11.3	37	33	30	CL
SSP17	soil	0	19	7.4	3.7	14	2.3	41	32	27	L
SSP17	spoil	19	52	5.6	10.3	9 (P)	5.4	37	31	32	CL
SSP18	soil	0	17	7.6	5.2	15	3.8	34	37	29	CL
SSP18	spoil	17	55	7.2	7.5	11	8.1	30	32	38	CL

* Increments shaded in bold and identified to be "unsuitable" based on soil chemistry analysis.

** Units are tons calcium carbonate per 1000 tons of material. Values listed are based on total sulfur percentage unless designated with a (P) where the pyritic sulfur was determined.

*** Soil texture presented for fine earth fraction of sample only. SL - sandy loam, L - loam, SCL - sandy clay loam, CL - clay loam, and C - clay.

TABLE 4.3.C.
Soil-Spoil Pedon (SSP) Analytical Data for Sites Located Within N-14.

Sample Location	Sample Medium	Sample Depth (Inches)	Sample Thickness (Inches)	pH	EC (mmho/cm)	ABP **	SAR	Sand (%)	Silt (%)	Clay (%)	Texture ***
SSP19	soil	0	11	7.6	0.6	10	0.4	76	10	14	SL
SSP19	soil	11	15	7.7	0.4	7	0.8	82	7	11	SL
SSP19	spoil	26	44	7.8	0.7	36	1.7	66	16	18	SL
SSP20	soil	0	22	7.4	3.2	17	0.7	45	29	26	L
SSP20	spoil	22	50	7.1	9.6	3	7.2	25	42	33	CL
SSP21	soil	0	18	7.5	3.7	6	2.1	77	11	12	SL
SSP21	spoil	18	54	6.6	**12.1***	23	12.6	57	22	21	SCL
SSP22	soil	0	16	7.7	0.6	23	0.4	69	14	17	SL
SSP22	spoil	16	56	**4.2***	6.4	2 (P)	3.7	57	23	20	SCL
SSP23	soil	0	11	7.5	0.6	25	0.3	64	20	16	SL
SSP23	soil	11	23	7.7	0.4	33	0.5	71	17	12	SL
SSP23	spoil	34	36	7.8	0.5	34	1.5	71	13	16	SL

* Increments shaded in bold and identified to be "unsuitable" based on soil chemistry analysis.

** Units are tons calcium carbonate per 1000 tons of material. Values listed are based on total sulfur percentage unless designated with a (P) where the pyritic sulfur was determined.

*** Soil texture presented for fine earth fraction of sample only. SL - sandy loam, L - loam, SCL - sandy clay loam, and CL - clay loam.

TABLE 4.4

Fertility Data(1) for Surface Soil Samples from J-1 and N-6.

Site ID(2)	OM (%)	N (ppm)	P (ppm)	K (ppm)	pH	Texture
SSP1	0.7	7	8	146	8.0	scl
SSP2	0.4	3	3	102	8.2	scl
SSP3	0.1	5	2	60	8.4	sl
SSP4	0.4	1	2	107	8.2	scl
SSP5	0.9	2	10	216	7.9	scl
SSP6	1.1	1	4	159	8.0	scl
SSP7	1.0	2	3	156	8.0	sl
MEAN	**0.7**	**3**	**5**	**135**	**8.1**	**scl**

(1) OM - organic matter, N - total nitrogen, P - phosphorus, K – potassium, sl – sandy loam, and scl – sandy clay loam.

(2) For location, see Map 4.1.A.

TABLE 4.5.A

Location(1) and Soil Thickness Verification (STV) Data for Sites Located Within J-1 and N-6.

Site ID	Easting(2) (Feet)	Northing(2) (Feet)	Soil Thickness (Feet)(3)
STV2	30,463	-20,233	5.0
STV3	34,861	-19,741	5.0
STV4	36,585	-13,789	5.0
STV5	35,088	-14,738	1.5
STV6	34,082	-15,286	2.5
STV7	34,798	-15,732	0.5
STV8	28,758	-18,529	4.0
STV9	29,053	-17,868	2.5
STV10	28,461	-18,011	1.5
STV11	28,267	-17,778	2.5
STV12	28,046	-17,563	2.5
STV13	27,798	-17,315	2.0
STV14	26,912	-17,511	2.0
STV15	26,525	-17,590	1.0
STV16	26,291	-17,471	1.0
STV17	26,962	-15,643	2.0
STV18	26,450	-15,621	1.5
STV19	26,376	-15,867	1.5
STV20	27,537	-14,306	2.0
STV21	27,478	-13,344	2.0
STV22	28,644	-13,500	0.5
STV23	28,596	-13,342	3.0
STV24	28,195	-13,125	1.5
STV25	27,735	-12,544	1.0
STV26	27,210	-11,855	1.0
STV27	26,562	-12,662	2.0
STV28	26,271	-12,419	2.5
STV29	25,731	-12,385	1.5
STV30	25,262	-12,815	1.5
STV31	24,676	-13,246	0.5
STV32	24,463	-13,566	2.0
STV33	24,751	-11,857	1.0
STV34	24,794	-11,501	2.0
STV35	23,801	-12,989	2.0
STV36	23,677	-12,713	1.5
STV37	23,886	-12,286	2.5
STV38	25,209	-10,425	1.0
STV39	23,407	-8,960	1.0
STV40	23,956	-9,012	2.5
STV41	24,301	-9,649	2.5
STV42	23,729	-10,822	3.0
STV43	25,594	-8,492	1.0
STV44	26,466	-7,781	2.0
STV45	26,607	-7,846	1.5
STV46	26,224	-8,413	2.0
STV47	26,315	-8,925	1.5
STV48	26,541	-6,411	1.0
STV49	31,675	-7,817	1.0
STV50	31,526	-7,836	2.0
STV51	30,465	-6,755	5.0
STV52	30,091	-6,554	2.0
STV53	30,766	-7,527	2.0
STV54	30,747	-8,323	1.0
MEAN	**---**	**---**	**2.0**

(1) For location see Map 4.1.A.
(2) PWCC coordinate system.
(3) Values measured to the nearest 0.5 foot.

TABLE 4.5.B

Location(1) and Soil Thickness Verification (STV) Data for Sites Located Within J-16.

Site ID	Easting(2) (Feet)	Northing(2) (Feet)	Soil Thickness (Feet)(3)
STV1	57,550	-17,734	2.0
STV55	50,745	-21,429	5.0
STV56	51,917	-22,076	2.0
STV57	51,306	-20,598	2.5
STV58	51,389	-20,660	1.5
STV59	51,505	-20,173	2.5
STV60	51,511	-19,447	4.0
STV61	51,663	-19,997	3.5
STV62	55,363	-24,851	2.0
STV63	54,970	-24,338	2.0
STV64	54,863	-23,569	1.0
STV65	53,215	-22,843	1.5
STV66	53,848	-22,794	0.5
STV67	52,543	-22,116	2.0
STV68	52,719	-22,420	2.0
STV69	56,349	-21,982	1.5
STV70	53,539	-20,662	1.5
STV71	53,732	-20,898	2.0
STV72	54,225	-19,477	1.5
STV73	55,801	-20,005	3.5
STV74	56,285	-18,527	3.0
STV75	55,792	-18,422	2.0
STV76	54,972	-19,209	1.5
STV77	59,817	-19,926	2.5
STV78	58,802	-19,436	1.0
STV79	58,484	-18,597	1.5
STV80	56,502	-17,599	0.5
STV81	52,880	-18,181	2.0
STV82	53,640	-18,301	1.5
STV83	54,868	-18,745	1.0
STV84	54,413	-17,939	5.0
MEAN	**---**	**---**	**2.1**

(1) For location see Map 4.1.B.

(2) PWCC coordinate system.

(3) Values measured to the nearest 0.5 foot.

TABLE 4.5.C

Location(1) and Soil Thickness Verification (STV) Data for Sites Located Within N-14.

Site ID	Easting(2) (Feet)	Northing(2) (Feet)	Soil Thickness (Feet)(3)
STV85	56,448	-8,614	0.5
STV86	54,430	-9,682	1.5
STV87	54,750	-10,190	2.0
STV88	57,488	-7,897	1.0
STV89	57,577	-7,230	1.5
STV90	58,148	-8,967	1.5
STV91	56,526	-10,058	1.0
STV92	55,770	-9,715	1.0
STV93	53,288	-10,674	2.0
STV94	53,025	-10,534	2.0
STV95	51,231	-12,244	1.0
STV96	55,449	-7,394	1.0
STV97	53,475	-11,737	1.0
STV98	54,027	-11,628	3.0
STV99	54,006	-11,999	1.0
STV100	54,251	-12,576	2.0
STV101	53,928	-12,208	2.0
STV102	51,474	-13,502	0.5
STV103	54,645	-8,232	0.5
STV104	54,858	-7,819	2.5
STV105	55,269	-8,521	1.0
STV106	52,497	-12,428	1.5
STV107	50,443	-11,801	1.0
STV108	50,408	-11,516	1.0
STV109	50,645	-10,782	1.0
STV110	50,894	-10,698	1.0
STV111	50,848	-10,891	1.0
STV112	51,336	-10,460	1.0
STV113	51,678	-9,470	1.5
STV114	50,825	-9,245	0.5
STV115	50,853	-10,170	0.5
STV116	50,716	-10,581	2.0
STV117	49,652	-10,662	2.0
STV118	49,263	-11,643	1.5
STV119	48,993	-7,612	1.0
STV120	49,701	-8,255	1.5
STV121	49,042	-8,502	1.5
MEAN	**---**	**---**	**1.3**

(1) For location see Map 4.1.B.

(2) PWCC coordinate system.

(3) Values measured to the nearest 0.5 foot.

TABLE 4.6

Suitability Criteria for Evaluating Soil. (1)

Parameter	Suitable	Marginal (2)	Unsuitable/ Restrictive
pH	5.5-8.5	5.0-5.5 8.5-9.0	<5.0 >9.0
Texture		c, sic, s	
SAR	0-10	10-12 (3) 10-15	<12 (3) >15
Conductivity (mmho/cm)	0-8	8-12	>12
Acid-Base Potential (4)	>0 if pH <6.0 >-5 if pH >6.0		<0 if pH <6.0 <-5 if pH >6.0

(1) As presented in Permit AZ-0001F, Volume 11A, Appendix A, Table 11 (PWCC, 2017).

(2) Soils with marginal suitability are evaluated for use on an individual basis.

(3) For fine-textured soils (clay >40%).

(4) Measured in tons $CaCO_3$ per 1000 tons of soil and based on pyritic sulfur fraction per permit AZ-0001F, Volume 11, Chapter 22, Table 11 (PWCC, 2017).

TABLE 4.7

Maximum Threshold Limits for Evaluating Recently Graded Spoil at the Kayenta Complex. (1)

Parameter	Major Root Zone (Subsoil-Spoil) 0 to 1 foot	Minor Root Zone (Substratum-Spoil) 1 to 3 feet
pH (sat. paste)	>8.8 <5.5	>9.0 <4.5
EC (mmhos/cm)	>12	>12
SAR		
< 20% clay	>25	>40
20-35% clay	>20	>35
>35% clay	>16	>25
Texture & Clay %	>45	>45
Rock Fragments %		
>2mm (by volume)	>65	>75
>3 inch (by volume)	>35	>40
Acid-Based Potential (2)	<0 if pH <6.0 <-5 if pH >6.0	<-5

(1) As presented in Permit AZ-0001F, Volume 11, Chapter 22, Table 11 (PWCC, 2017).

(2) Measured in tons $CaCo_3$ per 1000 tons of spoil and based on pyritic sulfur fraction per permit AZ-0001F, Volume 11, Chapter 22, Table 11 (PWCC, 2017).

TABLE 4.8

Recommended Fertility Levels for Native and Improved Range Grasses.

Parameter	Excellent	High	Moderate (1)	Low (1)	Reference
pH	6.1-7.3	5.6-6.0 7.4-7.8	5.0-5.5 7.9-8.9	>5.0 >8.9	(5), (7)
Organic Matter, %	>2.5	1.6-2.5	0.6-1.5	0-0.5	(2), (8)
Ammonium, ppm (2)	>15	10-15	5-9	0-4	(3), (6)
Nitrate, ppm (2)	>12	7-12	3-6	0-2	(2), (3), (4), (6)
Phosphorus, ppm ($NaHCO_3$)	>10	7-10	4-6	0-3	(2), (3), (6)
Potassium	>120	60-120	30-60	0-30	(2), (8)
Texture (9)	SIL, L	SL	CL, SCL SICL	S, LS, C SC, SIC	(8)

(1) Fertilizer applications may be beneficial when soil test values occur at these levels; however, phosphorus responses generally do not occur at the moderate suitability level (Berg, 1980).

(2) Nitrogen fertilization is not recommended when organic matter levels are greater than 2.0 percent (Barrett et. al., 1980).

(3) Berg, 1980.

(4) Hertzog, 1983.

(5) WDEQ, 1985.

(6) Sutton, et. al., 1981.

(7) Tiedemann and Lopez, 1982.

(8) USDA Forest Service, 1979.

(9) Texture codes are: S – sand, LS - loamy sand, SL - sandy loam, SIL - silt loam, L – loam, SICL - silty clay loam, SCL - sandy clay loam, CL – clay loam, SC - sandy clay, SIC - silty clay, C – clay.

TAB 5

Revegetation

N-6/J-1, J-16 and N-14

Reclamation Liability Release Application

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TAB 5 - REVEGETATION

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INTRODUCTION

Peabody Western Coal Company (PWCC) is requesting final release of reclamation liability on approximately 2,981 acres of surface coal-mined lands in the N-6, J-1, J-16 and N-14 reclaimed area referred to in following sections as reclaimed liability release areas (RLRA). These lands are subject to the postmining land use and revegetation performance standards in 30 CFR 715.20. Tab 5 contains information necessary for the regulatory authority to make its determination that the reclaimed portions of these lands have been successfully revegetated, and therefore qualify for final liability release. Tab 5 includes a review of the revegetation activities conducted in the release area, discussion of the applicable success standards, presentation of the sampling methods used to measure revegetation success, and presentation and discussion of the vegetation data needed to determine that revegetation success has been achieved. This information addresses the regulatory requirements and the applicable subjects identified in OSM's checklist for use in preparing applications for release of areas subject to 30 CFR, Subchapter B.

PRE- AND POSTMINING LAND USE

The mined lands identified in this release application were used as rangeland prior to disturbance. This land use includes rangelands and forest lands which support a cover of herbaceous or scrubby vegetation suitable for grazing or browsing (30 CFR 715.13(c)(6)). The objective of PWCC's revegetation plan for the RLRA was to restore postmining rangeland condition equal to or better than pre-mining rangeland condition, as well as provide habitat for wildlife. A discussion of the consultation process and determination of the pre- and postmining land use is presented in the 1981-1985 Mining and Reclamation Plan (MRP) submitted by PWCC to the U.S. Geological Survey, OSM, Bureau of Indian Affairs, and Navajo and Hopi Indian Tribes on January 6, 1981.

REVEGETATION SUCCESS STANDARDS

The regulations at 30 CFR 715.20(f) specify that revegetation success shall be measured on the basis of reference areas approved by the regulatory authority (OSM). In August 1979, PWCC retained the consulting firm Espey, Huston & Associates, Inc. (EH&A) to document the baseline ecology and vegetation of the Black Mesa leasehold and locate suitable reference areas. The reference areas were established on the basis of the EH&A studies by scientifically evaluating soils, vegetation, slope, and aspect such that each reference area matched a vegetation community to be disturbed by mining. The two plant communities characterized in the baseline studies that would be disturbed by mining included pinyon-juniper woodland and sagebrush shrubland.

Approximately 65 percent of the disturbance area was occupied by pinyon-juniper woodland. The remaining 35 percent of the disturbance area was occupied by sagebrush shrubland.

The baseline studies conducted by EH&A were included in the previously referenced MRP. The OSM's review of the MRP ultimately resulted in the reference areas being accepted as standards for judging revegetation success on interim program lands at the Kayenta Complex.

Six reference areas were originally established: two pinyon-juniper woodland reference areas near the N-7, N-8, and N-14 mining areas, and four sagebrush shrubland reference areas near the J-7, J-1, N-7, N-8, and J-16 mining areas. The original reference areas consisted of large, unfenced areas ranging in size from 31.7 acres to 230.2 acres. Each contained a 0.1-acre exclosure to be used to adjust for ongoing grazing effects in the larger areas. At the request of OSM, PWCC abandoned this design and expanded the 0.1-acre exclosures to a minimum size of 2 acres. At the same time, the J-1 sagebrush shrubland reference area was discarded. The enlarged enclosures were fenced in 1982.

The J-7 sagebrush shrubland, N-7/8 sagebrush shrubland and pinyon-juniper woodland, and N-14 sagebrush shrubland and pinyon-juniper reference areas were utilized in the revegetation success determinations for the N-6, J-1, J-16 and N-14 release area. The living plant ground cover comparison criterion (30 CFR 715.20(f)(2)) was developed from these reference areas in the following manner. The ground cover of living plants in the sagebrush reference areas was combined and averaged during each liability release sampling episode as were the pinyon-juniper cover values. The resulting averaged sagebrush and pinyon-juniper values were then combined, and a weighted average cover value was determined across all reference areas sampled.

The weighting was 35 percent sagebrush and 65 percent pinyon-juniper, representing the approximate split between these vegetation types in the disturbance areas as determined from baseline studies. Ground cover of living plants was defined as the non-overlapping ground cover of plants up to approximately one meter above the ground surface. Tall shrub and pinyon or juniper canopy above this level was not included in the cover measurement because it was considered canopy cover. Basal area coverage of pinyon and juniper tree stems was included in the ground cover criterion. Baseline studies showed that the combined average tree stem basal area for the N-14 and N-7/8 pinyon-juniper reference areas was 5002.7 dm^2/ha. This represents five percent ground cover which was added to the measured ground cover in the woodland reference areas prior to calculating the weighted cover success standard.

SUMMARY OF REVEGETATION ACTIVITIES

The revegetation methods applied on the N-6, J-1, J-16 and N-14 RLRA reflect the best technology currently available (BTCA) practices of the period. Grading to create a rolling, stable landform was conducted in the area. Salvaged topsoil was replaced primarily from established stockpiles and only a small portion of the areas received direct hauling of topsoil. Final grading and replacement of topsoil were conducted prior to the revegetation activities summarized below. Tab 4 (Minesoil Reconstruction) describes topsoiling procedures and any demonstrations of the spoil and topsoil suitability for plant growth.

Tillage

All reclaimed areas in the N-6, J-1, J-16 and N-14 RLRA were contour furrow disced using a modified Towner offset disc. The modified offset disc consists of a Towner large disc with the standard front gang retained and the rear gang modified to include 36-inch diameter discs spaced 36 inches apart. This creates furrows on the landscape that are 9 to 14 inches deep with 36-inch spacing between furrows. The contour furrow discing aided in surface stabilization by intercepting overland flow and reducing erosion. This also aided in vegetation growth by holding moisture in the furrows and allowing increased infiltration into the soil profile and root zone. Furrow remnants are still present in many of the N-6, J-1, J-16 and N-14 reclaimed areas.

Seeding and Reseeding

Table 5-1 lists the various plant species used during the 34 year period these RLRA’s were reclaim. As illustrated the seed mixtures evolved during the course of this period with the more recent 10 year period having the least change in species seeded. Map 5.1.A and 5.1.B illustrate the years of seeding within each of the RLRA area. Table 5-2 lists the total acres by year as well as the percentage of the total area of each RLRA as well as the overall total of all the RLRA’s included in the application. The N-6, J-1, J-16 and N-14 RLRA were drill seeded either with a rangeland type drill with twelve-inch row spacing or a Truax grass drill with eight-inch row spacing. Depth bands on both drills were attached to restrict seeding depth to one inch or less. The heavy discs and support arms on the rangeland drill made disc openers less effective, however.

The rangeland drill contained one seed box and the mix was not segregated based on varying seed characteristics or seeding depth. The Truax drill included three boxes and the seed was placed in the box best corresponding to seed mix characteristics (cool season type grasses dominant or fluffy/trashy seed dominant). The Truax drill was modified in 1997 to seed the drill and broadcast mixes simultaneously.

Table 5 - 1

Reclamation Seed Mix History for N-6, J-1, J-16 and N-14 RLRA Areas

(Seeding Years 1981 through 1992)

Species Scientific Name	Years of Reclamation Seeding with listed Species in the Mixture											
	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Introduced Perennial Grasses (Cool)												
Agropyron desertorum	X	X	X									
Agropyron intermedium	X	X	X									
Agropyron trichophorum				X	X	X	X	X	X	X	X	
Bromus inermis	X	X	X	X	X	X	X	X	X	X	X	
Elmus junceus	X	X	X	X	X	X	X	X	X	X	X	
Native Perennial Grasses (Cool)												
Agropyron dasystachyum				X	X	X	X	X	X	X	X	X
Agropyron smithii	X	X	X	X	X	X	X	X	X	X	X	X
Agropyron trachycaulum				X	X	X	X	X	X	X	X	X
Oryzopsis hymenoides	X	X	X				X	X	X	X	X	X
Native Perennial Grasses (Warm)												
Bouteloua curtipedula				X	X	X	X	X	X	X	X	X
Bouteloua gracilis	X			X	X	X						
Buchloe dactyloides							X	X	X	X	X	X
Eragrostis trichodes				X	X	X						
Hilaria jamesii				X	X	X						
Panicum virgatum				X	X	X						
Sporobolus airoides	X	X	X	X	X	X						X
Sporobolus cryptandrus	X	X	X	X	X	X						X
Introduced Biennial/Perennial Forbs												
Medicago sativa	X	X	X									
Melilotus officinalis	X	X	X	X	X	X						X
Native Perennial Forbs												
Linum lewisii				X	X	X	X	X	X	X	X	
Sphaeralcea ambigua				X	X	X			X		X	
Native Shrubs and Subshrubs												
Atriplex canescens	X	X	X	X	X	X	X	X	X	X	X	X
Atriplex confertifolia				X	X	X	X	X	X	X	X	X
Ceratoides lanata	X	X	X	X	X		X	X	X	X	X	
Purshia tridentata				X	X	X	X		X			

Table 5 - 1 Continued

Reclamation Seed Mix History for N-6, J-1, J-16 and N-14 RLRA Areas

(Seeding Years 1993 through 2004)

Species Scientific Name	Years of Reclamation Seeding with listed Species in the Mixture											
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Introduced Perennial Grasses (Cool)												
Agropyron trichophorum	X	X	X	X	X	X	X	X	X	X	X	X
Elmus junceus	X	X	X	X	X	X	X	X	X	X	X	X
Native Perennial Grasses (Cool)												
Agropyron dasystachyum	X	X	X	X	X	X	X	X	X	X	X	X
Agropyron inerme									X	X	X	X
Agropyron smithii	X	X	X	X	X	X	X	X	X	X	X	X
Agropyron trachycaulum	X	X	X	X	X	X	X	X				
Elymus cinereus	X	X	X	X	X	X	X	X				
Oryzopsis hymenoides	X	X	X	X	X	X	X	X	X	X	X	X
Schizachyrium					X							
Sitanion hystrix	X	X	X	X		X		X				
Native Perennial Grasses (Warm)												
Bouteloua curtipedula	X	X	X	X			X	X	X	X	X	X
Bouteloua gracilis	X	X	X	X	X	X			X	X	X	X
Buchloe dactyloides							X	X	X	X	X	X
Hilaria jamesii	X	X	X	X	X	X	X	X	X	X	X	X
Muhlenbergia wrightii					X							
Sporobolus airoides	X	X	X	X	X	X		X	X	X	X	X
Sporobolus cryptandrus					X				X	X	X	X
Introduced Biennial/Perennial Forbs												
Astragalus cicer							X					X
Medicago sativa					X							
Melilotus officinalis	X	X	X	X	X	X	X	X	X	X		
Onobrychis viciaefolia							X	X	X	X	X	X
Sanquisorba minor					X	X	X	X	X	X	X	X
Native Perennial Forbs												
Cleome serrulata							X					
Gaillardia aristata												
Linum lewisii	X	X	X	X	X	X	X	X	X	X	X	X
Penstemon palmeri	X	X	X	X	X	X		X	X	X	X	X
Penstemon strictus								X				
Petalostemon candidum	X	X	X	X	X							
Petalostemon purpureum					X							
Ratibida columnifera	X	X	X	X	X	X			X	X	X	X
Sphaeralcea ambigua					X							
Introduced Subshrubs												
Kochia prostrata									X	X	X	X
Native Shrubs and Subshrubs												
Atriplex canescens	X	X	X	X	X	X	X	X	X	X	X	X
Atriplex confertifolia	X	X	X	X	X	X	X	X	X	X	X	X
Ceratoides lanata	X	X	X	X	X	X			X	X	X	X
Purshia glandulosa				X	X				X	X		
Purshia tridentata		X	X			X	X				X	X

Table 5 - 1 Continued

Reclamation Seed Mix History for N-6, J-1, J-16 and N-14 RLRA Areas

(Seeding Years 2005 through 2018)

Species Scientific Name	Years of Reclamation Seeding with listed Species in the Mixture											
	2005	2006	2007	2008	2009	2011	2012	2013	2014	2016	2017	2018
Introduced Perennial Grasses (Cool)												
Agropyron trichophorum	X	X	X	X	X	X	X	X	X	X	X	X
Elmus junceus	X	X	X	X	X	X	X	X	X	X	X	X
Elymus lanceolatus											X	X
Native Perennial Grasses (Cool)												
Agropyron dasystachyum	X	X	X	X	X	X	X	X	X	X	X	X
Agropyron inerme	X	X	X	X	X	X						
Agropyron smithii	X	X	X	X	X	X	X	X	X	X	X	X
Agropyron spicatum							X	X	X	X	X	X
Oryzopsis hymenoides	X	X	X	X	X	X	X	X	X	X	X	X
Native Perennial Grasses (Warm)												
Bouteloua curtipedula	X	X	X	X	X	X	X	X				
Bouteloua gracilis	X	X	X	X	X	X	X	X	X	X	X	X
Buchloe dactyloides	X	X	X	X	X	X	X	X	X	X	X	X
Hilaria jamesii	X	X	X	X	X	X						
Panicum virgatum						X						
Sporobolus airoides	X	X	X	X	X	X	X	X	X	X	X	X
Sporobolus cryptandrus	X	X	X	X	X	X	X	X	X	X	X	X
Introduced Biennial/Perennial Forbs												
Astragalus cicer	X	X	X	X	X	X	X	X	X	X	X	X
Onobrychis viciaefolia	X	X	X	X	X	X	X	X	X	X	X	X
Sanquisorba minor	X	X	X	X	X	X	X	X	X	X	X	X
Native Perennial Forbs												
Gaillardia aristata	X	X	X	X	X	X	X	X	X	X	X	X
Linum lewisii	X	X	X	X	X	X	X	X	X	X	X	X
Petalostemon candidum	X	X	X	X	X	X	X	X				
Ratibida columnifera	X	X	X	X	X	X	X	X	X	X	X	X
Introduced Subshrubs												
Kochia prostrata	X	X	X	X	X	X	X	X	X	X	X	X
Native Shrubs and Subshrubs												
Atriplex canescens	X	X	X	X	X	X	X	X	X	X	X	X
Atriplex confertifolia	X	X	X	X	X	X	X	X	X	X	X	X
Ceratoides lanata	X	X	X	X	X	X	X	X	X	X	X	X

Table 5 - 2: Summary of Reclamation Seeding Years and Acres for the N-6, J-1, J-16 and N-14 RLRA Areas

Seeding Year	N-6 RLRA		J-1 RLRA		J-16 RLRA		N-14 RLRA		Summary	
	Acres	% of Total	Acres	% of Total	Acres	% of Total	Acres	% of Total	Acres	% of Total
1981	0.0	-	16.7	7.7	0.0	-	0.0	-	16.7	0.6
1982	40.4	3.8	30.6	14.2	0.0	-	0.0	-	71.0	2.4
1983	0.0	-	8.7	4.0	0.0	-	6.7	0.7	15.4	0.5
1984	0.0	-	0.0	-	1.5	0.2	45.7	5.0	47.3	1.6
1985	0.0	-	30.6	14.2	4.5	0.6	95.8	10.4	130.9	4.4
1986	16.7	1.6	26.0	12.0	57.8	7.4	46.6	5.1	147.0	4.9
1987	2.4	0.2	0.0	-	32.2	4.1	27.8	3.0	62.4	2.1
1988	0.0	-	0.0	-	72.5	9.3	0.0	-	72.5	2.4
1989	13.5	1.3	3.0	1.4	2.9	0.4	70.7	7.7	90.0	3.0
1990	27.9	2.6	66.5	30.8	34.3	4.4	61.6	6.7	190.3	6.4
1991	21.1	2.0	2.6	1.2	0.0	-	1.8	0.2	25.6	0.9
1992	41.6	3.9	0.5	0.2	105.1	13.4	124.3	13.5	271.5	9.1
1993	14.3	1.3	2.5	1.2	0.0	-	0.0	-	16.8	0.6
1994	76.7	7.2	0.0	-	7.4	0.9	0.0	-	84.1	2.8
1995	0.0	-	0.0	-	1.7	0.2	0.0	-	1.7	0.1
1996	51.9	4.9	0.0	-	0.0	-	5.0	0.5	56.9	1.9
1997	49.4	4.6	2.9	1.3	48.8	6.2	47.8	5.2	148.9	5.0
1998	29.9	2.8	0.0	-	0.6	0.1	2.0	0.2	32.5	1.1
1999	21.1	2.0	2.7	1.2	124.7	16.0	0.0	-	148.4	5.0
2000	42.7	4.0	0.0	-	6.9	0.9	160.5	17.4	210.1	7.0
2001	0.0	-	0.0	-	14.3	1.8	74.9	8.1	89.2	3.0
2002	0.0	-	0.0	-	24.0	3.1	14.8	1.6	38.8	1.3
2003	100.6	9.5	0.0	-	102.7	13.1	4.1	0.4	207.4	7.0
2004	70.3	6.6	0.0	-	15.5	2.0	4.6	0.5	90.5	3.0
2005	18.6	1.7	0.0	-	0.0	-	6.4	0.7	25.0	0.8
2006	207.3	19.5	0.0	-	0.0	-	0.0	-	207.3	7.0
2007	28.7	2.7	0.0	-	0.4	0.1	0.0	-	29.0	1.0
2008	1.1	0.1	0.0	-	18.8	2.4	9.4	1.0	29.3	1.0
2009	14.3	1.3	0.0	-	88.5	11.3	1.5	0.2	104.3	3.5
2010	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-
2011	101.4	9.5	0.0	-	0.0	-	6.7	0.7	108.1	3.6
2012	35.8	3.4	0.0	-	0.0	-	8.5	0.9	44.3	1.5
2013	35.3	3.3	16.1	7.4	4.1	0.5	5.0	0.5	60.5	2.0
2014	0.6	0.1	6.8	3.1	0.0	-	0.0	-	7.4	0.2
2015	0.0	-	0.0	-	0.0	-	0.0	-	0.0	-
2016	0.0	-	0.0	-	12.8	1.6	0.0	-	12.8	0.4
2017	0.0	-	0.0	-	0.0	-	23.2	2.5	23.2	0.8
2018	0.0	-	0.0	-	0.0	-	59.7	6.5	59.7	2.0
Not Seeded N14-F Pond							4.7	0.5	4.7	0.2
Totals	1063.6	100%	216.2	100%	782.0	100%	919.8	100%	2981.5	100%

Seeding was conducted in the spring, summer, and fall; however, the majority of N-6, J-1, J-16 and N-14 were seeded in the late summer or fall.

The information shown in Table 5-2 is based on information available from historical records available at the mine site. Beginning in 1999 PWCC began including the details of the specific mixtures in the OSM Annual Reclamation Report. While the information included is not complete for several years during the years of reclamation on the RLRA areas the vegetation data collected and presented in this section demonstrates that the ground cover is adequate to meet the regulatory requirements.

Fertilization

Fertilizer was applied from 1980 through 1983 at rates varying from 180 pounds per acre of 11-19-0 to 225 pounds per acre of 18-46-0. Fertilizer was not applied in 1984 and 1985. In 1986, 1987, 1988, 1989, and 1990 phosphate (0-45-0) was applied at a rate of 200 pounds per acre. In 1989 and 1990 nitrate (35-0-0) was applied at a rate of 200 pounds per acre. No areas were fertilized after 1990. The records do not indicate whether the applied fertilizer was incorporated.

Mulching

Early mulching activities included the use of barley cover crop/stubble mulch, and straw or hay mulching in the RLRA. Areas seeded from 1990 through 2016 were mulched with grass hay or barley straw at 2 tons per acre. All mulch was crimped.

Maintenance and Fencing

Maintenance and fencing activities have been conducted throughout the period of liability for the RLRA. Fencing in the RLRA was carried out over a period of years as reclamation operations in the area were completed. Fencing consists of 48-inch woven wire sheep tight fence topped by a single strand of barbed wire at 56 inches. Fence maintenance and repair has been ongoing during the liability period.

Maintenance of reclaimed areas has included rill and gully repair, reseeding, and trespass livestock removal. Trespass livestock have been removed whenever observed. Livestock grazing impacts have been localized and short-term. Vegetation has readily recovered following any grazing. Rill and gully repair have ranged from contour disking or ripping and reseeding of rills to import of topsoil with scrapers to fill larger gullies. These latter areas were then contour disced and seeded. Straw bales and mulch have been placed in rills and smaller gullies. Rocks down drains have been constructed in several drainages, principally in the western portion of the RLRA, to stabilize areas receiving large flow events.

VEGETATION SAMPLING METHODS

Introduction

Quantitative and qualitative vegetation sampling was conducted in the N-6, J-1 RLRA in fall of 2016 and 2017. The N-6 and J-1 RLRA areas were sampled as a one unit due to the small size of the J-1 area and are referred to as N-6/J-1 in the vegetation data section of the application. Sampling was conducted in the J-16 RLRA and the N-14 RLRA in fall of 2015 and 2016 as well as the reference areas during the corresponding RLRA sampling seasons and years. All samples were collected by an independent consulting firm Habitat Management Inc. (HMI) specializing in southwestern quantitative plant community evaluations. Samples were collected as close as possible to the "peak of green" during the spring or fall growing seasons to ensure optimal vegetation conditions were represented.

The primary objective of the vegetation sampling program was to measure the ground cover of living plants in the reference areas and reclaimed release units for the purpose of making direct comparisons pursuant to 30 CFR 715.20(f)(2). Species composition, frequency, and density data were collected in conjunction with the cover samples. Secondary objectives included measurement of production and woody plant density in the RLRA. The production, woody plant density, and species abundance data (frequency and species density) were collected in the RLRA’s for the purpose of assessing species diversity, distribution, seasonal variety, utility, and vigor pursuant to 30 CFR 715.20(f)(3).

Sample Randomization

All vegetation sampling was conducted in a random manner in order to allow all species and sample points (n-1) an equal opportunity of occurring in a given sample. Such an approach ensures that unbiased estimates of sample means and variances are obtained from the samples so that valid statistical evaluations can be made.

Sample point selection for the RLRA’s was accomplished using a random point generator/plotter script in ArcGIS 10 with a minimum buffer distance of 150-feet in reclaimed areas and 25-feet in reference areas. Sample points were stratified for reclaimed areas with multiple parcels and a random number generator was used to assign the sample number to each sample point. All GIS generated sample points were located in the field utilizing a GPS unit and photo/topobase map. Transect and quadrat (belt) density orientations were determined from a randomly selected number between 0 and 359. Slope and aspect were recorded at all sample points. Maps 5.2.A, 5.2.B and 5.2.C show vegetation sample point locations for the RLRA’s and the Reference Areas.

Cover Sampling

The ground cover of living plants (by species); the ground cover of rock, litter, lichens and moss; and bare ground cover were measured using a modified point intercept method (Buckner 1985; Viert 1985). The modification consisted of using a laser point bar. The modified point intercept method used in this study is the same method used for a number of years at the Kayenta Complex and by OSMRE for field sampling. The optical point bar apparatus was replaced by a laser point bar for sampling in 2013.

The laser point bar apparatus consists of two lasers mounted on a bar 1m in length. The bar is in turn attached to a standard camera tripod that can be leveled to compensate for uneven terrain. The tripod positions the bar above the ground cover vegetation (approximately 1.0m above ground surface) and the two lasers are projected vertically to the ground each 0.5m away from and perpendicular to the transect center line.

Cover samples were collected along a 50m transect. Two points were read at each 1.0 meter interval along each transect resulting in a total of 100 points. The two points were read on either side of the transect while the bar was positioned perpendicular to the transect. First hit cover was recorded separately from additional downward hits to differentiate stratified and non-stratified cover. Overstory (canopy) hits were not used in the success evaluations since only the ground cover of living plants must be measured for revegetation success determinations on the RLRA and reference areas.

The ground cover of living plants separated by species, and the ground cover of rock, litter, lichen and moss was calculated by dividing the number of first hit interceptions for a particular species or material by the total number of points taken on each transect (100). First hit relative vegetation cover was calculated by dividing first hit cover for each species by the first hit vegetation cover. Stratified vegetation cover was calculated by dividing all hits (first, second, etc.) for a particular species by the total number of points taken (100).

Plant Species Frequency, Constancy, and Density

Absolute frequency of each plant species, rock, litter, and lichen and moss was calculated by dividing the number of transects on which the species or material was observed (i.e., hit) by the total number of samples collected in a given sampling area. Relative frequency of each plant species was calculated by dividing the absolute frequency of that species by the total plant species frequency in the sample and expressing the result as a percent.

During the course of cover sampling, all plant species occurring within one meter on either side of each cover sample transect were noted as "present" within the sample. This measure of species density or abundance was calculated by dividing the number of samples in which a species occurred (either hit on the transect or counted as present in the 2m x 50m belt defined by the transect) by the total number of samples collected in a given sampling area. Species density is reported as the average number of species per 100 square meters.

Production Sampling

Production samples were collected in the RLRA's during each season within the year sampling was conducted. Production samples were collected utilizing a "total harvest" method. Three 0.5m circular quadrats were placed systematically at specified intervals along each 50m cover transect, one meter out to the left in the spring and one meter to the right in the fall. This avoids clipping plants whose parts might be intercepted during concurrent cover sampling. All current years' growth of herbaceous vegetation and woody plants were clipped in a vertical projection within the plot boundaries, separated by species, and placed in labeled paper bags. Clipped materials were dried in forced-draft ovens at 30° C for 48 hours, and then weighed to the nearest 0.1 gram.

Mean plant species dry weight production in the sampling area was calculated by dividing the sum of the dry weights of each species in a sample by the total number of plots sampled in the area and converting to grams per square meter and pounds per acre. Relative production was calculated by dividing the mean production of each species by the mean total production measured in the sample area.

Woody Plant Density Sampling

Woody plant density samples were collected in the N-6/J-1, J-16 and N-14 RLRA's during each seasonal sample conducted in the years of sampling. Woody plant density was measured using direct counts of individual shrubs for each species rooted within 2m x 50m quadrats (belt transects) oriented along the cover transects.

Woody plants were further categorized into height classes. The height classes were 0.0 to 20.0 cm, 21.0 to 50.0 cm, and greater than 50 cm. Mean density by species and density by height class were calculated by dividing the sum of each woody plant species or of each woody plant species by height class counted in all quadrats by the total number of quadrats sampled and converting the value to accepted unit area figures. Relative density was calculated by dividing the mean woody plant density for each species by total mean woody plant density in a given sample area.

Sample Adequacy

The adequacy of the cover samples collected in each sagebrush shrubland reference area and the N-6/J-1, J-16 and N-14 RLRA's was evaluated utilizing the following equation:

$$N_{min} = \frac{t^2\ s^2}{d^2\ x^2}$$

where,

^{n}min = the minimum sample size

t = the tabular t-statistic (t 0.10(1), df = n-1)

s = the sample standard deviation (n-1 degrees of freedom)

d = 0.1 (level of precision or desired detectable reduction)

x = the sample mean

The sample means, sample standard deviations, and variances were based on the total non-stratified ground cover of living plants measured on each transect in a given sampling area during each discrete sampling event (season and year).

Experience with collecting vegetation cover samples in the pinyon-juniper woodland on the Black Mesa leasehold and applying the previously described sample adequacy equation (or variations thereof) to the data has shown that inordinately large sample sizes are often required. The above equation is sensitive to the assumptions of data normality, symmetry, kurtosis, and/or data sets containing zeros. Data sets from pinyon-juniper plant communities can have high variances and usually form bimodal or Poisson distributions.

The cover data sets collected in the pinyon-juniper reference areas were transformed prior to applying the previously discussed equation to improve normality and distribution. These transformations are recommended for data sets exhibiting the characteristics of those collected in pinyon-juniper woodlands on the Black Mesa leasehold (Steele and Torrie 1960; Zar 1974).

The data transformation calculation used for nearly all data sets from the N-14 and N-7/8 pinyon-juniper reference areas was applied as follows.

$$X_{at} = \sin^{-1}\sqrt{(X+1)/100}$$

where,

X = the total non-stratified live vegetation ground cover below 1 meter of the "a"th sample

X_{at} = transformed cover value

Following transformation of the data set and calculation of a transformed mean and standard deviation, sample adequacy was determined using the above described sample adequacy equation.

RESULTS AND DISCUSSION

Data summaries for the N-6/J-1, J-16 and N-14 RLRA vegetation monitoring studies supporting this liability release application are presented in Appendices 5-1 through 5-3. These appendices represent both reference area and the RLRA data. The data in each of these appendices is organized in chronological order by season and year. Within a season and year, the RLRA data summaries are organized in the following order: cover summary, production summary and woody plant density summary (Appendix 5-1). The pinyon-juniper reference area summaries are contained in Appendix 5-3 and the sagebrush reference areas are in Appendix 5-2. The monitoring results for the RLRA and reference areas containing full data may be found in the annual vegetation monitoring reports corresponding to the appropriate years for the Kayenta Complex (2015, 2016 and 2017).

Sample Adequacy

A summary of sample adequacy calculations for total non-stratified vegetation ground cover in the N-6/J-1, J-16 and N-14 RLRA is presented in Table 5-3. The sagebrush shrubland and pinyon-juniper woodland reference area sample adequacy calculations are presented in Table 5-4. Adequate samples for total non-stratified living plant cover in the sagebrush shrubland reference areas and the RLRA's were obtained in all sample areas during each sampling period within the years sampled. Sample adequacy in the pinyon-juniper reference areas was achieved using an arcsine transformation as described earlier in this section.

Cover Success Standard

The seasonal cover sample data and summaries for the N-6/J-1 , J-16 and N-14 RLRA's, the two pinyon-juniper woodland reference areas and the three sagebrush shrubland reference areas are presented in Appendices 5-1 through 5-3, respectively. The calculations used to combine and obtain a weighted mean cover standard for purposes of demonstrating revegetation success are presented in Table 5-5. The methods for deriving the cover standard were explained in the previous section entitled "Revegetation Success Standards". In each season and year, the ground cover of living plants in the N-6/J-1, J-16 and N-14 RLRA exceeded the cover success standard, indicating revegetation success has been achieved with respect to the requirements at 30 CFR 715.20(f)(2).

Table 5 - 3: Summary of Sample Adequacy Calculations for Samples in the N-6/J-1, J-16 and N-14 RLRA and Sagebrush Shrubland and Pinyon-Juniper Woodland Reference Areas

		Sample Adequacy Parameters[2]					
Site ID[1]	Sample Period	x	s	t	d	n	n(min)
J-16 RLRA	Fall 2015	34.5	8.6	1.328	0.1	20	11
	Fall 2016	29.5	9.8	1.325	0.1	21	20
N-14 RLRA	Fall 2015	30.8	9.2	1.337	0.1	17	17
	Fall 2016	30.4	9.0	1.333	0.1	18	16
N-6/J-1 RLRA	Fall 2016	33.2	7.5	1.33	0.1	19	10
	Fall 2017	28.7	8.2	1.328	0.1	20	15

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[1] Site Identification Number - Site name as follows: N-6/J-1, J-16 and N-14 RLRAs = N-6/J-1, J-16 and N-14 Reclaimed Liability Release Areas

[2] Sample Adequacy Parameters:

x = sample mean (total non-stratified live vegetation ground cover)

s = sample standard deviation

t = tabular t-statistic (t 0.10(1), df = n-1)

d = precision level

n = sample size

n (min) = minimum sample size

Table 5 - 4: Sample Adequacy Summary for the Sagebrush Shrubland and Pinyon-Juniper Woodland Reference Areas

		Sample Adequacy Parameters[2]					
Site ID[1]	Sample Period	x	s	t	d	n	n(min)
J7RASAGE	Fall 2015	40.8	7.8	1.345	0.1	15	7
	Fall 2016	36.5	5.8	1.345	0.1	15	5
	Fall 2017	35.0	5.4	1.345	0.1	15	5
N7/8RASAGE	Fall 2015	28.3	5.7	1.345	0.1	15	8
	Fall 2016	32.2	7.2	1.345	0.1	15	9
	Fall 2017	31.7	7.2	1.345	0.1	15	10
N14RASAGE	Fall 2015	38.1	3.6	1.345	0.1	15	2
	Fall 2016	42.6	8.5	1.345	0.1	15	8
	Fall 2017	41.5	3.4	1.345	0.1	15	2
N7/8RAPJUN	Fall 2015[3]	12.3[5]	6.6[6]	1.345	0.1	15	14[4]
	Fall 2016[3]	11.8[5]	3.8[6]	1.345	0.1	15	5[4]
	Fall 2017[3]	9.1[5]	4.6[6]	1.345	0.1	15	11[4]
N14RAPJUN	Fall 2015[3]	12.5[5]	3.7[6]	1.337	0.1	17	16[4]
	Fall 2016[3]	9.1[5]	4.1[6]	1.345	0.1	15	9[4]
	Fall 2017[3]	14.7[5]	5.3[6]	1.345	0.1	15	7[4]

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[1] Site Identification Number - Site name as follows:

J7RASAGE = J-7 Sagebrush shrubland reference area
N7/8RASAGE = N7/8 Sagebrush shrubland reference area
N14RASAGE = N-14 Sagebrush shrubland reference area
N7/8RAPJUN = N7/8 pinyon-juniper woodland reference area
N14RAPJUN = N-14 pinyon-juniper woodland reference area

[2] Sample Adequacy Parameters as shown in Table 5-3, footnote 2.

[3] Transformed data using $X_{at} = \sin^{-1}\sqrt{(X+1)/100}$

[4] n(min) following arcsine transformation

[5] Arithmetic mean shown in table above. Arcsine transformation used for adequacy calculation resulted in transformed and reconstituted in lower means. The higher arithmetic mean above is applied to performance standard testing. Arcsine (x+1) transformed means and standard deviations for the PJ reference data used for adequacy calculation are as follows:

AREA	Season / Year	Arcsine mean	Arcsine Std Dev
N7/8RAPJUN	Fall 2015	0.36347	0.10009
	Fall 2016	0.36228	0.05851
	Fall 2017	0.31541	0.07707
N14RAPJUN	Fall 2015	0.37272	0.05500
	Fall 2016	0.31660	0.07040
	Fall 2017	0.40164	0.07643

[6] Standard deviations associated with the arithmetic mean. Values associated with the arcsine transformed data shown immediately above.

Pinyon-Juniper Reference Area Cover

Total non-stratified live vegetation ground cover ranged from 9.1 percent in both the N-7/8 pinyon-juniper reference area in fall 2017 and the N-14 pinyon-juniper reference area in fall 2016 to 14.7 percent in the N-14 pinyon-juniper reference area in fall 2017 (Table 5-5). Averaged non-stratified live vegetation ground cover for the N-7/8 and N-14 pinyon-juniper reference areas was lowest in the fall of 2016 at 10.4 percent and highest at 12.4 percent in fall 2015. Litter ranged from 28.0 percent in the N-14 pinyon-juniper reference area in fall 2015 to 42.5 percent in the N-7/8 reference area during the fall of 2017 (Appendix 5-3). Rock cover ranged from 24.9 percent in the N-14 pinyon-juniper reference area in fall 2017 to 40.6 percent in the N-7/8 pinyon-juniper reference area in fall 2015. Litter and rock cover were greatest in the woodland reference areas among all reference and reclaimed areas sampled averaging 34.1 percent litter cover and 33.3 percent rock cover during the period of sampling.

Table 5 - 5: Summary Calculations for Revegetation Success Determinations Based on Total Live Non-Stratified Vegetation Ground Cover

	Total Non-Stratified Live Vegetation Ground Cover		
Site ID[1]	Fall 2015	Fall 2016	Fall 2017
J-16 RLRA	34.5	29.5	
N-14 RLRA	30.8	30.4	
N-6/J-1 RLRA		33.2	28.7
J7RASAGE	40.8	36.5	35.0
N7/8RASAGE	28.3	32.2	31.7
N14RASAGE	38.1	42.6	41.5
RASAGE (Average)	35.7	37.1	36.1
N7/8RAPJUN	12.3	11.8	9.1
N14RAPJUN	12.5	9.1	14.7
RAPJUN (Average)	12.4	10.4	11.9

Cover Standard Calculation[2]:

Fall 2015 Cover Standard = (35.7) (0.35) + (12.4 + 5) (0.65) = 23.8 (0.9) = 21.4
Fall 2016 Cover Standard = (37.1) (0.35) + (10.4 + 5) (0.65) = 23.0 (0.9) = 20.7
Fall 2017 Cover Standard = (36.1) (0.35) + (11.9 + 5) (0.65) = 23.6 (0.9) = 21.2

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[1] Site Identification Number = Site name as follows:
J-16, N-14, N-6/J-1 RLRAs = J-16, N-14, N-6/J-1 Reclaimed Liability Release Areas
J7RASAGE = J-7 region sagebrush shrubland reference area
N7/8RASAGE = N7/8 region sagebrush shrubland reference area
N14RASAGE = N-14 region sagebrush shrubland reference area
N7/8RAPJUN = N7/8 region pinyon-juniper woodland reference area
N14RAPJUN = N-14 region pinyon-juniper woodland reference area

[2] Cover standard as required under 30 CFR 715.20(f) (2)

The tree component, consisting of seedling, sapling, and mature vegetation below one meter in height dominated the cover in the N-14 pinyon-juniper reference area in each sampling season and year. Pinyon pine (Pinus edulis), Utah juniper (Juniperus osteosperma), and Gambel oak (Quercus gambelii) were represented. The shrub/sub-shrub component was relatively constant, contributing significantly to total non-stratified cover, depending upon season and year. Broom snakeweed (Gutierrezia sarothrae) was a dominant shrub. Native perennial forbs can be a significant component of cover in the N-14 pinyon-juniper reference area.

In the N-7/8 pinyon-juniper reference area native trees and native shrubs contributed similarly to total non-stratified live vegetation ground cover during each sampling period. Gambel oak was not represented. The shrub component was dominated by fourwing saltbush (Atriplex canescens) and big sagebrush (Artemisia tridentata). Native perennial herbaceous species are well represented in this reference area but do not contribute greatly to total vegetation cover.

Sagebrush Shrubland Reference Area Cover

Total non-stratified live vegetation ground cover ranged from 28.3 percent in the N-7/8 sagebrush shrubland reference area in fall 2015 to 42.6 percent in the N-14 sagebrush shrubland reference area in the fall of 2016. Average non-stratified live vegetation ground cover for all three sagebrush shrubland reference areas was lowest in fall 2015 at 35.7 percent and highest at 37.1 percent in fall 2016 (Table 5-5). Litter cover was highly variable in the three sagebrush reference areas and ranged from 10.9 percent in the J-7 sagebrush shrubland reference area in fall 2015 to 20.0 percent in the same reference area during fall 2017 (Appendix 5-2). Litter cover can be high in the sagebrush reference areas and averaged 15.6 percent over the sampling period.

Rock cover was consistently greatest in the N-7/8 sagebrush shrubland reference area during each season while the N-14 reference area had little or no rock. Values for rock cover ranged from 8.4 to 19.5 percent over the sampling period in the N-7/8 sagebrush shrubland reference area.

The shrub component, consisting mostly of big sagebrush, comprised the majority of total non-stratified live vegetation ground cover in the N-7/8 and N-14 sagebrush shrubland reference areas during each season and was the second most common component in the J-7 sagebrush reference area. The graminoid component, consisting primarily of warm season native perennial grasses, was dominant in the J-7 area and also well represented in the other sagebrush shrubland reference areas each season. Blue grama (Bouteloua gracilis) was most commonly encountered but squirreltail (Sitanion hystrix or S. longifolium) was also prevalent. Sub-shrubs contributed a significant amount of cover in the J-7 sagebrush shrubland reference area, primarily due to the occurrence of Greene's rabbitbrush (Chrysothamnus greenei).

N-6 / J-1, J-16 and N-14 RLRA Cover

J-16 RLRA Cover

Total non-stratified live vegetation ground cover was 34.5 percent in fall 2015 and 29.5 percent in fall 2016 (Table 5-5 and Appendix 5-1). Litter cover decreased from 11.6 percent in fall 2015 to 8.7 percent in fall 2016. Rock cover, consistently less than that found in most of the reference areas, was 2.6 percent in fall 2015 and 3.4 percent in fall 2016.

The grass component, consisting primarily of introduced cool season perennial grasses, comprised the majority of total non-stratified live vegetation ground cover in the J-16 RLRA in both fall 2015 and 2016. Total non-stratified live vegetation ground cover for this life form was 18.3 percent in 2015 and 11.5 percent in 2016. The predominant species was Russian wildrye (Elymus junceus). Native warm season perennial grasses, primarily alkali sacaton (Sporobolus airoides) and blue grama, also contributed 7.6 percent and 9.3 percent in 2015 and 2016, respectively. Native shrubs, almost exclusively fourwing saltbush were the other important species contributing cover of 3.8 percent in 2015 and 3.9 percent in 2016.

N-14 RLRA Cover

Total non-stratified live vegetation ground cover in the N-14 RLRA was consistent with 30.8 percent in fall 2015 and 30.4 percent in fall 2016 (Table 5-5 and Appendix 5-1). Litter cover was also relatively consistent with 11.4 percent in 2015 and 9.8 percent in 2016. Rock cover, consistently less than that found in the pinyon-juniper reference areas but greater than that found in most of the sagebrush shrubland reference areas, was 6.4 percent in 2015 and 4.1 percent in 2016.

The grass component, consisting primarily of introduced cool season perennial grasses, comprised the majority of total non-stratified live vegetation ground cover in the N-14 RLRA in both 2015 and 2016. Total non-stratified live vegetation ground cover for this life form was 15.3 percent in 2015 and 14.2 percent in 2016. The predominant species was Russian wildrye in both years. A difference in 2015 was the contribution of native perennial warm season grasses at 5.8 percent cover compared to only 1.6 percent cover in 2016. Native shrubs, primarily fourwing saltbush, provided cover of 4.1 percent in 2015 and 4.2 percent in 2016.

N-6/J-1 RLRA Cover

Total non-stratified live vegetation ground cover in the N-6 / J-1 RLRA was 33.2 percent in fall 2016 and had decreased to 28.7 percent in fall 2017 (Table 5-5 and Appendix 5-1). However, litter cover was higher in fall 2017 at 15.8 percent compared to 11.9 percent in fall 2016. Rock cover, consistently less than that found in most of the reference areas, was 3.0 percent in fall 2016 and 2.9 percent in 2017.

Introduced perennial cool season grasses were the dominant life form cover in both years with 15.6 percent cover in fall 2016 and 13.6 percent cover in fall 2017. The principle species was Russian wildrye. Native perennial cool season and warm season grasses were also well represented with a combined cover of 10.1 percent in 2016 and 7.9 percent in 2017. Native shrubs, primarily fourwing saltbush, were also an important lifeform with 5.4 percent cover in 2016 and 4.5 percent cover in 2017.

RLRA Revegetation Success Characterization

Revegetation success criteria stipulates that the ground cover of living plants in the reclaimed area must be 90 percent of that found in the approved reference area for a minimum of two growing seasons. Using Tables 5-3, 5-4 and 5-5 as reference, this success criterion was met in each of the three RLRA's for two growing seasons.

An effective vegetative and hydrologic cover has been established in the N-6/J-1, J-16 and N-14 RLRA's that has stabilized the reclaimed landforms and minimized erosion. Analyses presented in Tab 3 (Protection of the Hydrologic Balance) demonstrate the established cover in the three RLRA's is effective in maintaining sediment yields in reclaimed watersheds at required criteria. Sediment yield modeling presented in Tab 3 indicate that mean annual sediment yields from reclaimed watersheds are comparable to or lower than sediment yields from similar sized watersheds in the premine areas encompassing the RLRA's.

All prominent species (perennial grasses and shrubs) observed in the N-6/J-1, J-16 and N-14 RLRA's reflect approved seed mixes, revegetation methods, and best technology practices at the time and are a function of successional processes and trends in these revegetation communities. The section "Species Diversity and Distribution" includes a detailed discussion of the establishment and development of reclaimed plant communities in response to the applied reclamation technologies. Production and utility of the revegetated communities to meet the approved postmining land uses are presented in the following sections.

Production

Production sampling was conducted during each of the sampling seasons achieving a minimum of two years of production data for each of the three RLRA's. Production data and summaries for the N-6/J-1, J-16 and N-14 RLRA may be found in Appendix 5-1. A seasonal production summary for prominent life forms and species for each RLRA is presented in Table 5-6. Livestock carrying capacity and utility related to production data are discussed in following sections of this tab.

Table 5 - 6: Production Summary by Sampling Season and Year for Prominent Life Forms and Species in the N-6/J-1, J-16 and N-14 RLRA

	Mean Values[1]					
	N-6/J-1 Fall 2016	N-6/J-1 Fall 2017	J-16 Fall 2015	J-16 Fall 2016	N-14 Fall 2015	N-14 Fall 2016
Total Production	373.8	364.3	753.6	487.7	714.5	457.1
Primary Life Form[2]	ICPG	ICPG	ICPG	ICPG	ICPG	ICPG
Production	217.2	170.7	290.9	206.6	248.4	289.8
Secondary Life Form	NWPG	NWPG	NWPG	NWPG	NWP	NWP
Production	94.3	52.4	260.6	206.2	160.0	59.9
Primary Species[3]	Elyjun	Elyjun	Elyjun	Elyjun	Elyjun	Elyjun
Production	214.5	164.8	290.9	200.6	234.4	271.7
Secondary Species	Atrcan	Kocpro	Spoair	Bougra	Atrcan	Atrcan
Production	31.7	36.9	205.7	100.1	91.0	58.9
No. of species	16	16	20	12	22	20

[1] Values are in pounds per acre

[2] Life Form: ICPG = Introduced cool season perennial grass
NWPG = Native warm season perennial grass
NWP = Native woody plants (shrubs and subshrubs)

[3] Species Code: Elyjun = Elymus junceus
Atrcan = Atriplex canescens
Kocpro = Kochia prostrata
Spoair = Sporobolus airoides
Bougra = Bouteloua gracilis

Production in the N-6/J-1 RLRA was somewhat similar for both sampling periods ranging from 373.8 pounds per acre in fall 2016 to 364.3 pounds per acre in fall 2017 (Table 5-6). In both sampling seasons, introduced cool season perennial grasses predominated by Russian wildrye had the highest production of any life form. The second highest production level was contributed by native warm season perennial grasses in both years. Other important native species included blue grama, galleta (Hilaria jamesii), alkali sacaton, western wheatgrass (Agropyron smithii, and fourwing saltbush.

Production in the J-16 RLRA varied considerably between the falls of 2015 and 2016, with 2015 sampling recording over 1.5 times the amount of annual production as 2016. Precipitation in the spring and summer of both years was above average, but 2015 precipitation was considerably higher than 2016 contributing to a significant increase in production. Production in fall 2015 totaled 753.6 pounds per acre and in fall 2016 had fallen to 487.7 pounds per acre (Table 5-6). Introduced cool season perennial grass was the dominant life form in both years at 290.9 pounds per acre in 2015 and 209.6 pounds per acre in 2016. Russian wildrye was the dominant species in both years. In both 2015 and 2016 native warm season perennial grasses were the largest secondary contributor to production, dominated by alkali sacaton in 2015 and blue grama in 2016. Native shrubs, primarily fourwing saltbush, were a significant contributor in 2015 with 125.3 pounds per acre, but had decreased to 30.7 pounds per acre in 2016.

Production in the N-14 RLRA was also impacted by the very wet spring/summer conditions in 2015 and this is reflected in that season's data. Production in fall 2015 totaled 714.5 pounds per acre but had fallen to 457.1 pounds per acre in 2016 (Table 5-6). In both years, introduced cool season perennial grass was the greatest contributor to production at 248.4 pounds per acre in 2015 and 289.8 pounds per acre in 2016. Russian wildrye was the primary species in this life form in both years. Unlike the other RLRA's, native shrubs, principally fourwing saltbush, provided the next greatest level to production in both years. Native cool and warm season perennial grasses were well represented in contributions to total production and included galleta, alkali sacaton, blue grama and western wheatgrass in both years.

For the most part, species seeded in the N-6/J-1, J-16 and N-14 RLRA's (Table 5-1) are represented in the stands but Russian wildrye was consistently the dominant species. This is not unexpected based on seeding rates used in these older reclaimed areas and the competitive ability of this species. The seeded introduced species are, for the most part, well adapted to site conditions on Black Mesa having been selected as cultivars from similar habitats in Eurasia and are able to maintain good forage production during drier periods. Native or introduced perennial forbs are not well represented in production samples. Native warm season perennial grasses were heavily seeded in both areas and represented the second largest contributing lifeform in all three areas. A number of native forbs, sub-shrubs, and shrubs have become established in the RLRA, but contribute little to production.

Woody Plant Density

Woody plant density was measured in all sampling seasons/years for the N-6 / J-1, J-16 and N-14 RLRA's. Detailed data and summaries may be found in Appendix 5-1. A seasonal density summary for prominent shrubs for the RLRA's in each season and year is presented in Table 5-7. As discussed earlier under Methods, shrub data were collected by height classes during all sample seasons. The 0 to 20 cm class was established as a class reflecting seedlings or juveniles of the larger shrubs and thus an indicator of woody plant expansion or regeneration. The remaining two classes are a further indicator of structural (or age) diversity in the stand.

Woody plant density in the N-6/J-1 RLRA decreased from 1891.4 stems per acre in fall 2016 to 1566.1 stems per acre in fall 2017 (Table 5-7). Density was highly variable in the RLRA as evidenced by the typically high standard deviation values within each season that are often greater than the mean value (see tables in Appendix 5-1). Fourwing saltbush was the dominant shrub in this RLRA during both sampling periods with a consistent representation of 1086.3 stems per acre in 2016 and 1072.4 stems per acre in 2017. Woody plants of secondary importance in the RLRA were different in the two sampling seasons. The subshrub forage kochia (Kochia prostrata) was the most important secondary woody species in 2016 but broom snakeweed (Gutierrezia sarothrae) was the more dominant secondary woody plant in 2017. These two species were third most dominant species in each year as well. There were four subshrubs and five shrubs present in both years.

Table 5 - 7: Woody Plant Density Summary by Sampling Season and Year for Prominent Shrubs in the N-6/J-1, J-16 and N-14 RLRA

	Mean Values[1]					
	N-6/J-1 Spring 2016	N-6/J-1 Fall 2017	J-16 Spring 2015	J-16 Spring 2016	N-14 Spring 2015	N-14 Spring 2017
Total Density	1891.4	1566.1	2721.5	2233.5	3594.6	2407.9
Primary Species[2]	Atrcan	Atrcan	Kocpro	Kocpro	Kocpro	Kocpro
Density	1086.3	1072.4	1465.0	1138.9	2080.6	1297.2
Secondary Species[2]	Kocpro	Gutsar	Atrcan	Atrcan	Atrcan	Atrcan
Density	415.3	283.3	1054.2	786.2	1254.0	627.3
Tertiary Species[2]	Gutsar	Kocpro	Gutsar	Gutsar	Cerlan	Gutsar
Density	187.4	95.1	159.9	281.4	116.6	420.4
No. of Shrub Species	9	9	7	6	8	6

[1] Values are in number of stems per acre

[2] Species codes: Atrcan = Atriplex canescens
Gutsar = Gutierrezia sarothrae
Kocpro = Kochia prostrata
Cerlan = Ceratoides lanata

In the J-16 RLRA, woody plant density ranged from 2721.5 stems per acre in fall 2015 to 2233.5 stems per acre in fall 2016 (Table 5-7). Density is highly variable in these reclaimed areas as evidenced by typically high standard deviations associated with the data and as a result of random sample locations. In both sampling seasons forage kochia was the dominant woody species with 1465.0 stems per acre in 2015 and 1138.9 stems per acre in 2016. Fourwing saltbush was the secondary woody species in both sampling seasons followed by broom snakeweed as the third level woody species in both sampling periods. In 2015, there were four subshrubs and three shrubs encountered in the sampling. In 2016 there were three each of subshrubs and shrubs.

The N-14 RLRA was had substantially greater woody density in 2015 with 3594.6 stems per acre compared to only 2407.9 stems per acre in 2016 (Table 5-7). Forage kochia was the dominant woody species in the J-16 RLRA accounting for 58 percent of the density in 2015 and 54 percent of the density in 2016. Fourwing saltbush was the second most common woody plant and the subshrubs winterfat (Ceratoides lanata) and broom snakeweed were the third most important woody plants in 2015 and 2016, respectively. Woody density variability in the N-14 RLRA was highest of all three RLRA's. There were four subshrubs and four shrubs present in 2015 and three subshrubs and three shrubs present in the 2016.

Three to five shrub species were seeded in the N-6 / J-1, J-16 and N-14 RLRA's. In all, eleven native shrubs and subshrubs and one introduced subshrub were documented in the RLRA's. Fourwing saltbush was the more common seeded shrub species in the RLRA and normally had the highest seeded density of the shrub component. In older seeded areas of the RLRA's, the seeding rate was lower for this species (0.6 PLS per square foot) contributing to lower potential density of shrubs. By 1986 and onward, fourwing saltbush seeding rates were increased as much as fourfold. In areas that were seeded during the late spring or summer, fourwing saltbush density tends to be higher and is consistent with the literature as being more successful when done in the spring or mid-summer (Wasser, 1982). Fourwing saltbush has a range of site adaptabilities, good seedling vigor and ease of establishment and thus is common on all reclaimed areas.

Beginning in the late 1980's an emphasis was placed on fourwing saltbush seed sources that were from collection areas in the southwest that had been identified as having tetraploid accessions that reduce opportunities for sterile hybridization in offspring. This aids in the sustainability of fourwing saltbush in the reclamation when associated with best practices as noted above. Seedling class (0-20cm height class) was documented in all sampling periods as an aid in evaluating regeneration of fourwing saltbush. In the N-6 / J-1 RLRA, seedlings represented 10 percent of the fourwing density in fall 2016 and were even higher in fall 2017 when they comprised 23 percent of the fourwing density. The J-16 RLRA was similar to the N-6 / J-1 RLRA with 11 percent fourwing seedling density in fall 2015 and 25 percent in 2016. The N-14 RLRA was consistent in the two sampling periods with 10 percent in fall 2015 and 13 percent in 2016. Note that all three RLRAs have been under a managed grazing program for a number of years.

Species Diversity and Distribution

The following discussion on diversity and distribution is based on N-6/J-1, J-16 and N-14 RLRA cover data summaries contained in Appendix 5-1. Table 5-8 summarizes species distribution by life form for the season and year of sampling for these RLRA's and includes the number of species within each lifeform as well as the total for all lifeforms. The total number of species observed over three sampling seasons in the RLRA's ranged from a low of 20 in J-16 in fall 2016 to a high of 46 in N-14 in fall 2015. Total species numbers remained high in the N-14 RLRA with 37 tallied in fall 2016. In J-16 the total number of species reduced in half from 42 to 20 over a period of one year. Total species remained consistent in the N-6/J-1 RLRA with 33 species in 2016 and 32 in 2017.

The reclaimed areas are most similar to the sagebrush reference areas in terms of soils and topographic configuration species in life forms and total species numbers tend to reflect that. As can be seen in Table 5-8, the average sagebrush reference area total species counts ranged from 26 in fall 2015 to 22 in fall 2017. When the sagebrush and pinyon juniper reference areas are averaged together the total species numbers are increased somewhat with a low of 27 in fall 2016 to a high of 31 in fall 2015. The total species numbers in the reclaimed areas tend to be higher due to increased annual composition and the applied seed mixes containing a diversity of species. The variation in total species numbers and in life forms can be due to any number of factors including climatic conditions surrounding the sampling period, random sample site variation, and the environmental conditions acting upon the site since establishment.

The seed mixes presented earlier in this section are quite similar and were used uniformly in the revegetation process in the three RLRA's. Seeding season climatic variation and site conditions at the time of seeding can have a widely varying effect on outcomes when all other factors are more or less constant. The amount and distribution of precipitation in the growing season can vary significantly across the Kayenta Complex lease area and will affect variation in establishment and development. Considering these factors and the relatively early successional status of the reclaimed areas, species diversity is well represented and is a good reflection of applied best practices and the ecological potential of the sites.

The total number of species with relative cover greater than one percent (RC > 1%) is a good indicator of species diversity in established communities. Earlier successional communities such as reclaimed lands tend to have a greater presence of annual and biennial species than more successionally advanced communities. As communities advance successionally, there are a greater number of perennial species with relative cover greater than one percent and are representative of dominant and codominant species. Still, even in well-developed and successionally advanced communities they represent only a portion of the total species present as demonstrated by the reference area data in Appendices 5-2 and 5-3.

Table 5 - 8: Total Observed Species by Life Form with Relative Cover Greater Than One Percent for the N-6/J-1, J-16 and N-14 RLRA

	N-6/J-1 Fall 2016		N-6/J-1 Fall 2017		J-16 Fall 2015		J-16 Fall 2016		N-14 Fall 2015		N-14 Fall 2016	
	Total	>1% RC	Total	>1% RC	Total	>1% RC	Total	>1% RC	Total	>1% RC	Total	>1% RC
Introduced Annual Biennial Forbs	2	0	3	0	5	1	1	0	5	0	6	0
Native Annual Biennial Forbs	2	0	1	0	8	0	2	0	9	0	6	0
Introduced Perennial Forbs	1	0	1	0	0	0	0	0	0	0	0	0
Native Perennial Forbs	4	0	2	0	5	0	0	0	9	0	6	0
Introduced Annual Grasses	0	0	1	1	0	0	1	0	0	0	0	0
Native Annual Grasses	3	0	0	0	1	0	0	0	1	0	1	0
Introduced Cool Season Perennial Grasses	4	1	2	1	3	1	3	1	4	2	5	2
Native Cool Season Perennial Grasses	4	2	6	4	6	1	3	2	4	1	4	3
Native Warm Season Perennial Grasses	4	3	6	2	7	3	3	2	6	5	3	2
Native Sub-Shrubs	3	0	3	0	3	1	2	0	3	0	2	1
Introduced Sub-Shrubs	1	1	1	1	1	1	1	1	1	1	1	1
Shrubs	5	2	5	2	3	1	3	1	4	2	3	1
Succulents	0	0	1	0	0	0	1	0	0	0	0	0
Total	33	9	32	11	42	9	20	7	46	11	37	10
Species Density[1]	7.7		7.5		8.2		5.4		15.7		8.1	
Ave SB Ref Area	23	6	22	8	26	8	23	6	26	8	23	6
Ave SB Sp. Dens.[1]	9.24		9.84		10.8		9.24		10.8		9.24	
Ave All Ref Area	27	9	28	9	31	10	27	9	31	10	27	9
Ave All Ref Area Sp. Dens.[1]	10.7		11.2		13.5		10.7		13.5		10.7	

[1] Species Density = Average number of species per $100m^2$

Table 5-8 shows that N-6/J-1 had 9 and 11 species with RC >1% in 2016 and 2017, respectively. The J-16 RLRA went from nine to seven species with RC > 1% from 2015 to 2016 and the N-14 RLRA went from 11 to 10 in the same period. These values are slightly greater than those for the average sagebrush reference values of between six and eight depending on the year and season of sampling. The reclaimed area values are similar to the averaged combined sagebrush and pinyon juniper reference area values of 9 to 10.

Species density or the number of species per 100 square meters is another measure useful in evaluating diversity, particularly species richness. The RLRA species density values ranged from 5.4 in the J-16 RLRA in fall 2016 to 15.7 in the N-14 RLRA in fall 2015 (Table 5-8). The corresponding average sagebrush reference area values ranged from 9.2 in fall 2016 to 10.8 in fall 2015. As noted earlier, the reclaimed lands are most similar to the sagebrush reference areas and these species density values provide another reflection of the similarity and an indicator of successional development.

The habitat and community characteristics for the pinyon-juniper type, including plant growth substrates and topographic configuration, contribute to greater species density values. Averaged sagebrush and pinyon-juniper reference areas species density values also reflect this. Nevertheless, the reclaimed area species density values presented in Table 5-8 reflect a good measure of diversity considering the earlier successional status of these communities, the reclamation inputs and cultural practices and the arid and highly variable regional climate.

The distribution of growth forms and species within the reclaimed areas are influenced by the many factors noted previously. However, additional factors include long and short-term factors or goals and ecological variables such as interactions between species. An important and necessary short-term goal is surface stabilization and this is reflected in the dominance of grass cover, particularly cool season grasses. The primary postmine land use of livestock grazing has resulted in reclamation with a strong presence of introduced and native cool season and warm season grasses on reclaimed lands.

Cool season grasses are most dominant on the reclaimed lands and include a strong presence of Russian wildrye with varying presence of western wheatgrass, Indian ricegrass and thickspike wheatgrass. Blue grama, alkali sacaton and galleta are important warm season grasses and are present in all RLRA’s. Generally, eight to nine shrub and subshrub species can be found in the RLRA’s with fourwing saltbush dominating. Perennial forbs are variable in presence in the RLRA’s and while a number are seeded, the forbs present reflect more the immigration of species from adjacent native areas.

The percentage of native species relevant to all species encountered in the RLRA’s varied between 68 percent and 79 percent but was greater than 75 percent in four out of the six sampling periods for all RLRA’s. The total number of native species in the RLRA’s ranged from 36 in fall 2015 in N-14 to 14 in J-16 in fall 2016. The above analysis further supports that the reclaimed lands are diverse, sustainable and predominated by native species.

Utility

The N-6/J-1, J-16 and N-14 RLRA’s have a high level of utility for all classes of livestock and a variety of wildlife. Wildlife species are similarly benefited. Seed mixes were formulated to provide good forage production and nutrient levels and palatability. This utility is greatest during the spring growing season and to a somewhat lesser degree later in the summer and early fall reflecting the regional climate and bimodal precipitation pattern of the region. The herbaceous dominated reclaimed areas also provide potential forage resources outside of the primary growing seasons as standing hay and during warmer winter conditions when stands may experience additional green-up. The various grasses in these reclaimed units have the potential for high production levels, have good palatability and exhibit desirable forage nutrient characteristics throughout much of the year.

Desert wheatgrass, present in some areas of the RLRA, has the greatest utility during the spring growing season with lesser utility during fall regrowth (Heath et al., 1985). Russian wildrye, a primary species throughout all three RLRA’s, has a very long season of use and high digestibility through much of the year. It retains good nutrient qualities as standing hay in the winter (Hafenrichter et al., 1979). Russian wildrye also exhibits good regrowth and recovery after grazing and when spring moisture and summer rains are likely.

These qualities make this grass a valuable species throughout the year and compliment the other reclamation species in the PWCC grazing management program. Smooth brome and pubescent wheatgrass are less common species in the RLRA’s, but have traits somewhat similar to Russian wildrye. Smooth brome and pubescent wheatgrass are palatable to all classes of livestock, have good digestibility, possess good nutrient quality into summer and have moderate forage quality late season (Hafenrichter et al., 1979 and Cook et al., 1977).

Cool season native grasses, primarily thickspike wheatgrass, western wheatgrass, and Indian ricegrass are common and important species in the reclaimed areas but may not be significant contributors to overall production. Thickspike wheatgrass has finer leaves than western wheatgrass and is less coarse. It has good palatability and remains green in summer with good fall re-growth. Its lower production potential is offset by its sod-forming habit and surface stabilization potential (Wasser 1982).

Western wheatgrass is most palatable and offers the greatest utility when green in the spring, dropping off significantly as the grass matures (Cook et al., 1977). Western wheatgrass matures later than other cool season grasses and thus compliments the stands by extending the forage season. Indian ricegrass is well adapted to site conditions at Black Mesa and field observations indicate reproduction and increase of the species is good. Indian ricegrass is a palatable species offering good forage early and midway in the season and as standing hay later in the season (Hafenrichter et al., 1979).

Warm season native grasses are found throughout the reclaimed areas and contributed between 7 and 4% of the annual forage production in the RLRA areas. All warm season grasses present in the RLRA’s have good forage qualities during the growing season and blue grama maintains these qualities after the growing season (Cook et al., 1977). Blue grama has the greatest palatability, forage quality and utility of the warm season grasses. Alkali sacaton is a significant producer but has its greatest utility early in the season when green and palatable. Galleta has a good presence in the reclaimed lands and during its green growing period, forage value is good but drops off quickly after maturity (Stubbendieck et al., 1982). Sand dropseed has limited occurrence in the RLRA’s. The remaining warm season grass species in the RLRA’s are of generally limited occurrence.

Many of the forbs and shrubs offer forage nutrition that compliments the grass dominated communities and aid in balancing the overall forage nutritional quality. Fourwing saltbush, commonly found throughout the RLRA’s, is an excellent source of nutrients for all classes of livestock throughout the year (Cook et al., 1977). It provides valuable forage and browse to livestock and wildlife in the summer and into the fall and winter. Winterfat is a valuable browse species for livestock and wildlife, having high crude protein levels and providing succulent forage in the winter (Stubbendieck et al., 1982).

Forage kochia, a subshrub, was included in the applied seed mixes and commonly occurs in the RLRA’s. It is highly palatable throughout the year and has excellent protein content - a limiting nutrient on native range in the region (Kettle and Davison 1998). The commonly occurring annual species, fireweed summercypress, can be a significant contributor to annual production during wetter springs and in the fall. This species is used by livestock, particularly when green, and has good nutrient qualities (Cook et al., 1977). Generally, perennial forb presence in the RLRA's is limited in any given year and their contribution to forage intake is limited.

Table 5-9 lists livestock preferences for important species found in the N-6/J-1, J-16 and N-14 RLRA areas. These provide an indication of forage value for these species and a further means of evaluating utility. The species listed are those most commonly found in the RLRA's as determined from cover and production summary data for the season and years of sampling. Preferences for species such as desert wheatgrass, alkali sacaton, galleta, and western wheatgrass are based on stage of development. When these species are green and succulent they can be preferred forage. Other species such as Indian ricegrass, blue grama or Russian wildrye may maintain a high level of preference after maturing as standing hay. As can be seen from Table 5-9 a majority of the species found in the RLRA's have high levels of preference for all three livestock classes.

Table 5 - 9: Livestock Preference for Important Species in the N-6/J-1, J-16 and N-14 RLRA's

		Livestock Preference[1]		
		Cattle	Sheep	Horses
Agropyron dasystachyum	Thickspike wheatgrass	M	M	M
Agropyron desertorum	Desert wheatgrass	H	H	H
Agropyron intermedium	Intermediate weheatgrass	H	H	H
Agropyron smithii	Western wheatgrass	H	M	H
Agropyron spicatum	Bluebunch wheatgrass	H	H	H
Agropyron trachycaulum	Slender wheatgrass	H	H	H
Atriplex canescens	Fourwing saltbush	H	H	M
Bouteloua curtipendula	Sideoats grama	H	H	H
Bouteloua gracilis	Blue grama	H	H	H
Bromus inermis	Smooth brome	H	H	H
Ceratoides lanata	Winterfat	H	H	H
Elymus junceus	Russian wildrye	H	M	H
Hilaria jamesii	Galleta	M	M	H
Kochia prostrata	Forage kochia	M	M	L
Kochia scoparia	Summercypress	H	H	H
Oryzopsis hymenoides	Indian ricegrass	H	H	H
Sitanion hystrix	Squirreltail	M	M	M
Sphaeralcea coccinea	Scarlet globemallow	M	M	H
Sporobolus airoides	Alkali sacaton	H	M	H
Sporobolus cryptandrus	Sand dropseed	M	M	M

[1] Preference codes: H = high; M = medium; L = low

Table 5-10 lists livestock carrying capacity values for the N-6/J-1, J-16 and N-14 RLRA's. The figures are based on production data for the appropriate season and year of sampling. In determining the carrying capacity values, allowable use forage values for species were determined from proper use factors for cattle which have been assigned by the BIA (Bureau of Indian Affairs). In the absence of BIA assigned factors, a 50 percent proper use factor was assigned to species known to be used as livestock forage. It was assumed that one animal unit requires 900 pounds of forage for a month (one animal unit month or AUM).

Table 5 - 10: N-6/J-1, J-16 and N-14 RLRA Livestock Carrying Capacity Figures for Periods of Sampling

Area and Season	Total Usable Forage (lb/ac)[1]	Acre/Suyl[2]	Acre/Auyl[3]	Acre/Aum[4]
N-6/J-1 Fall 2016	371	14.6	58.2	4.9
N-6/J-1 Fall 2017	347	15.6	62.2	5.2
J-16 Spring 2015	720	7.5	30.0	2.5
J-16 Spring 2016	477	11.3	45.3	3.8
N-14 Spring 2015	647	8.3	33.4	2.8
N-14 Spring 2016	442	12.2	48.9	4.1

[1] Total usable forage is derived from proper use factors for cattle and production data. Does not include standing hay from previous year’s growth.

[2] Acres required to support one sheep unit for one year.

[3] Acres required to support one animal for one year.

[4] Acres required to support one animal unit for one month. Four sheep units are equal to one animal unit.

Use factors for cattle were used as a basis because this is becoming the primary kind of livestock run on Black Mesa. Livestock carrying capacity figures for the RLRA’s varied from a low of 2.5 acres/AUM in fall 2015 in the J-16 RLRA to a high of 5.2 acres/AUM in the N-6/J-1 RLRA in fall 2017. Table 5-10 shows corresponding carrying capacity values for sheep units.

Seasonal livestock carrying capacity figures have been determined for the two predominant native plant communities over the leasehold as presented in Table 18, Chapter 9, Vegetation (AZ-0001E PAP). The premine vegetation for the affected lands consisted of approximately 65 percent pinyon-juniper and 35 percent sagebrush shrubland. The average premine carrying capacity for the affected lands based on the Table 18 values and weighted by the native vegetation community composition, is estimated at 81 acres/AUM for the spring season and 128 acres/AUM for the fall season.

As can be seen in the seasonal carrying capacity figures for the N-6/J-1, J-16 and N-14 RLRA’s presented in Table 5-10, the reclaimed areas greatly exceed the native vegetation community carrying capacity in both seasons. The calculated carrying capacity, combined with the forage quality and high livestock preferences for the type of vegetation present in the RLRA’s, demonstrate that the reclaimed areas have a high level of utility

Seasonal Variety

Revegetation best practices, applied seed mixes and the vegetation community characteristics established in the N-6/J-1, J-16 and N-14 RLRA’s have been detailed in previous sections of this document. The level of seasonal variety present in the RLRA’s is a function of revegetation methods, response of the seeded mixes based on their composition and species characteristics, environmental factors, competition scenarios, successional development and inherent characteristics of warm season seeded species. Seasonal variety for purposes of this discussion is centered mostly on cool season and warm season grasses and woody plants.

Review of cover and production data summaries in Appendix 5-1 shows warm season grasses have a significance presence in all RLRA’s. Over the sampling periods, seven warm season grasses were observed across the six RLRA datasets. Warm season grasses contributed more to production in the RLRA’s (relative production of 7 to 42 percent) than has been seen in past liability release monitoring. Increasing frequency for these species indicates continued development and expansion of warm season grasses in reclaimed lands. Fourwing saltbush and forage kochia, both woody species, are important warm season forage species and provide excellent forage biomass while balancing forage nutritional qualities.

Cool season grasses in the RLRA’s provide year-long forage and benefit seasonal variety equal to or better than warm season species. The cool season grasses respond well to the bimodal precipitation patterns, providing spring, summer, and fall forage production with winter green-up also a possibility. Warm season grasses are more restricted to the summer forage producing season in response to summer monsoon moisture and warmer temperatures. On reclaimed lands, the dominant presence of cool season grasses provides quantity and quality of forage over a large portion of the year. The cool season grasses provide good standing hay crops for winter grazing. Thus, the more dominant presence of cool season grasses has actually enhanced seasonality.

Plant Vigor

Plant vigor, or the current state or health of plants, is a rather abstract term that is both difficult to measure and evaluate. Quantitative vegetation studies such as those conducted in the RLRA during the three sampling seasons are not structured to collect specific information useful in measuring plant vigor. However, several parameters evaluated during vegetation studies, combined with empirical observations provide indicators of plant vigor.

Drought conditions have been prevalent in the southwest for some time. In spite of this, the reclaimed plant communities continue to be productive and have increasing species establishment, cover and productivity. The ability of the RLRA’s to respond to favorable precipitation patterns is an indication of vigor. Fourwing saltbush recruitment in the reclaimed areas is common. Managed livestock grazing has occurred in the RLRA’s and these areas recover well and continue to meet success criteria. Finally, the RLRA’s continue to meet revegetation success criteria under the climatic regimes of the region and the managed grazing programs.

Plant communities in the RLRA’s have established under adverse climatic and arid site conditions experienced on Black Mesa. These plant communities have persisted and maintained a vigor which allows significant response to favorable environmental conditions, high potential productivity, and reproduction of major species in the RLRA’s.

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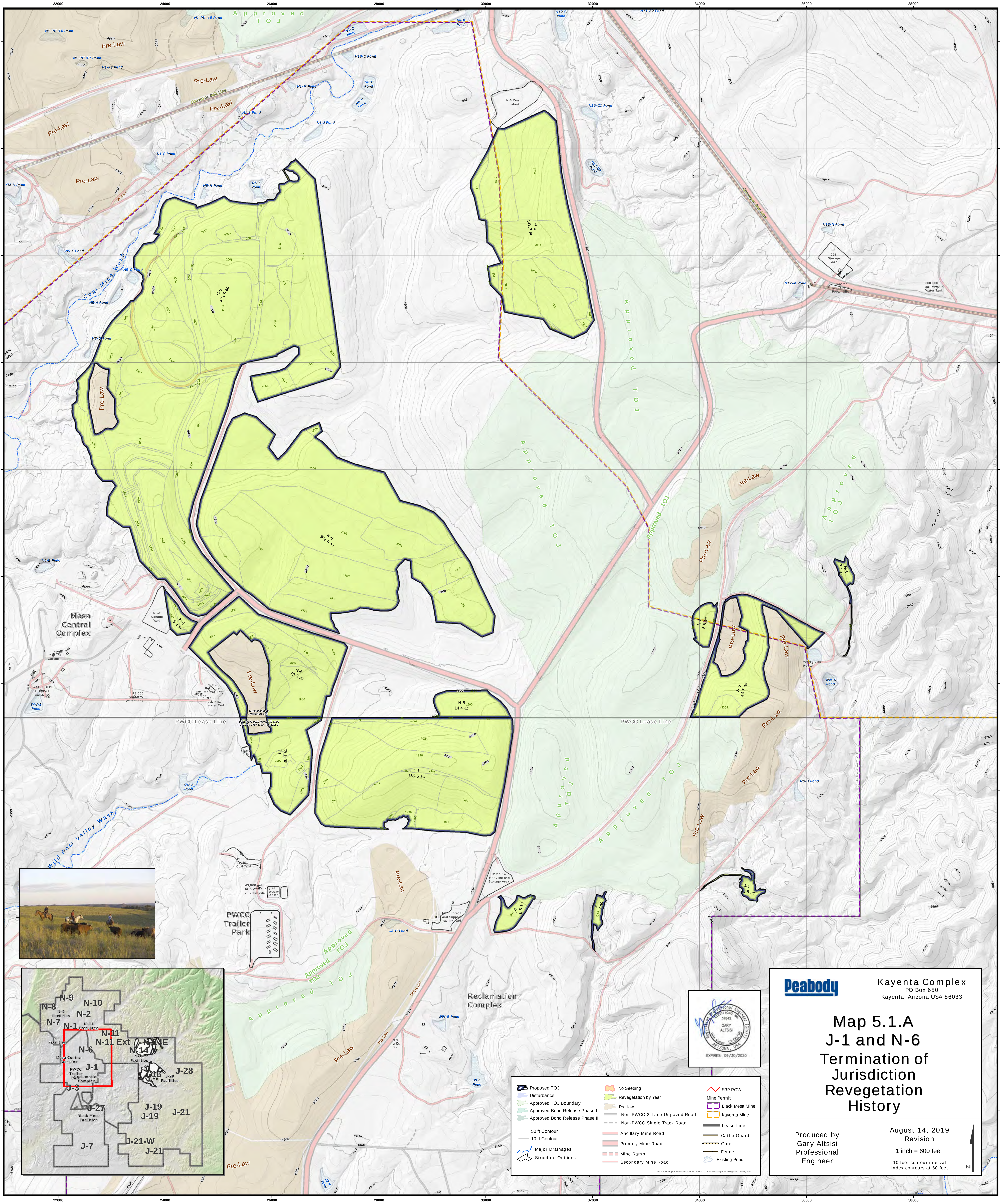

Peabody

Kayenta Complex
PO Box 650
Kayenta, Arizona USA 86033

Map 5.1.A
J-1 and N-6
Termination of Jurisdiction Revegetation History

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CERTIFICATE NO. 37842
GARY ALTSISI
Date signed: 12/05/18
ARIZONA, USA
EXPIRES: 09/30/2020

Produced by
Gary Altsisi
Professional
Engineer

August 14, 2019
Revision

1 inch = 600 feet

10 foot contour interval
Index contours at 50 feet

N

- Proposed TOJ
- Disturbance
- Approved TOJ Boundary
- Approved Bond Release Phase I
- Approved Bond Release Phase II
- 50 ft Contour
- 10 ft Contour
- Major Drainages
- Structure Outlines
- No Seeding
- Revegetation by Year
- Pre-law
- Non-PWCC 2-Lane Unpaved Road
- Non-PWCC Single Track Road
- Ancillary Mine Road
- Primary Mine Road
- Mine Ramp
- Secondary Mine Road
- SRP ROW
- Mine Permit
  - Black Mesa Mine
  - Kayenta Mine
- Lease Line
- Cattle Guard
- Gate
- Fence
- Existing Pond

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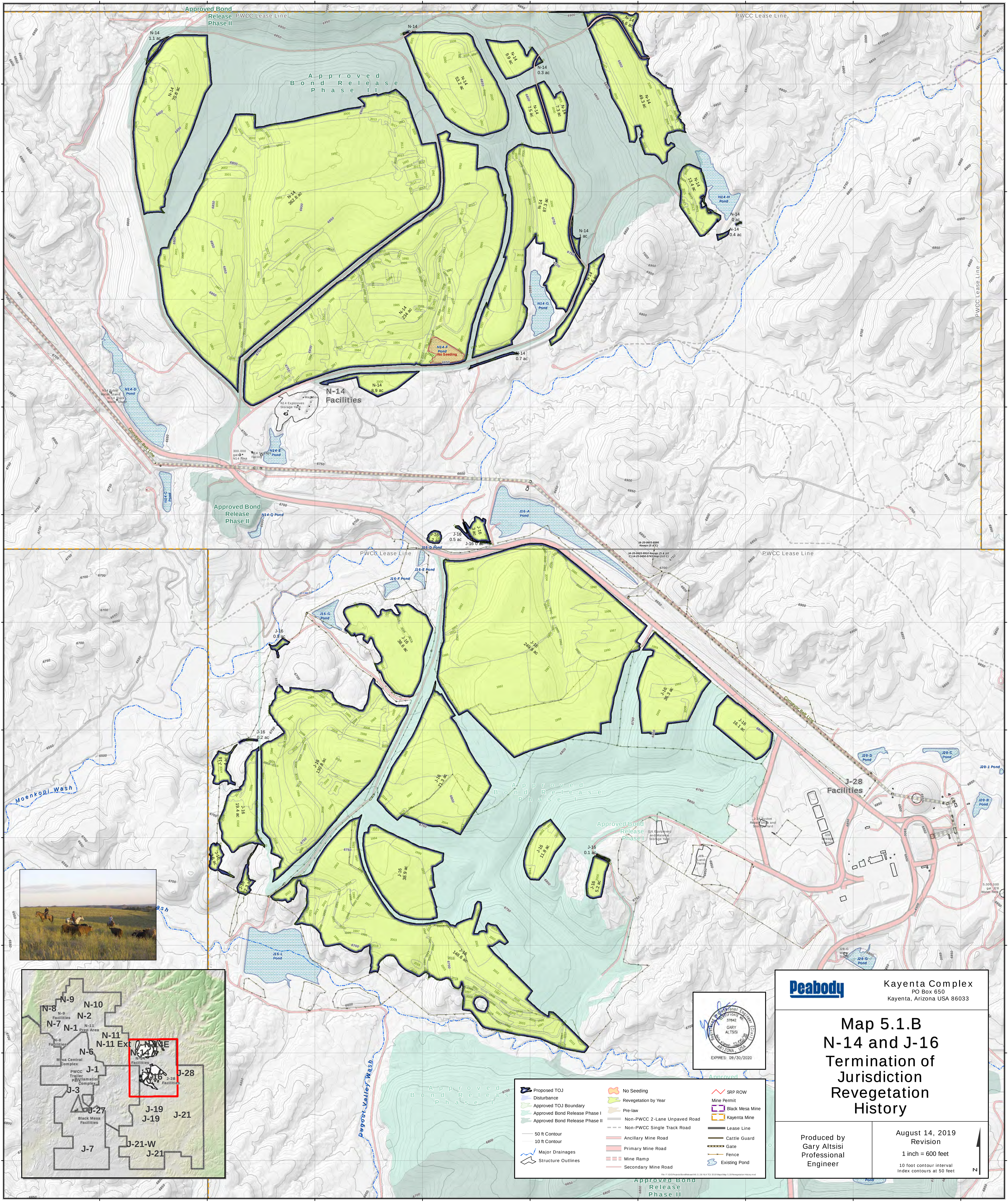

Proposed TOJ
Disturbance
Approved TOJ Boundary
Approved Bond Release Phase I
Approved Bond Release Phase II
50 ft Contour
10 ft Contour
Major Drainages
Structure Outlines
No Seeding
Revegetation by Year
Pre-law
Non-PWCC 2-Lane Unpaved Road
Non-PWCC Single Track Road
Ancillary Mine Road
Primary Mine Road
Mine Ramp
Secondary Mine Road
SRP ROW
Mine Permit
Black Mesa Mine
Kayenta Mine
Lease Line
Cattle Guard
Gate
Fence
Existing Pond

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Map 5.1.B
N-14 and J-16
Termination of Jurisdiction Revegetation History

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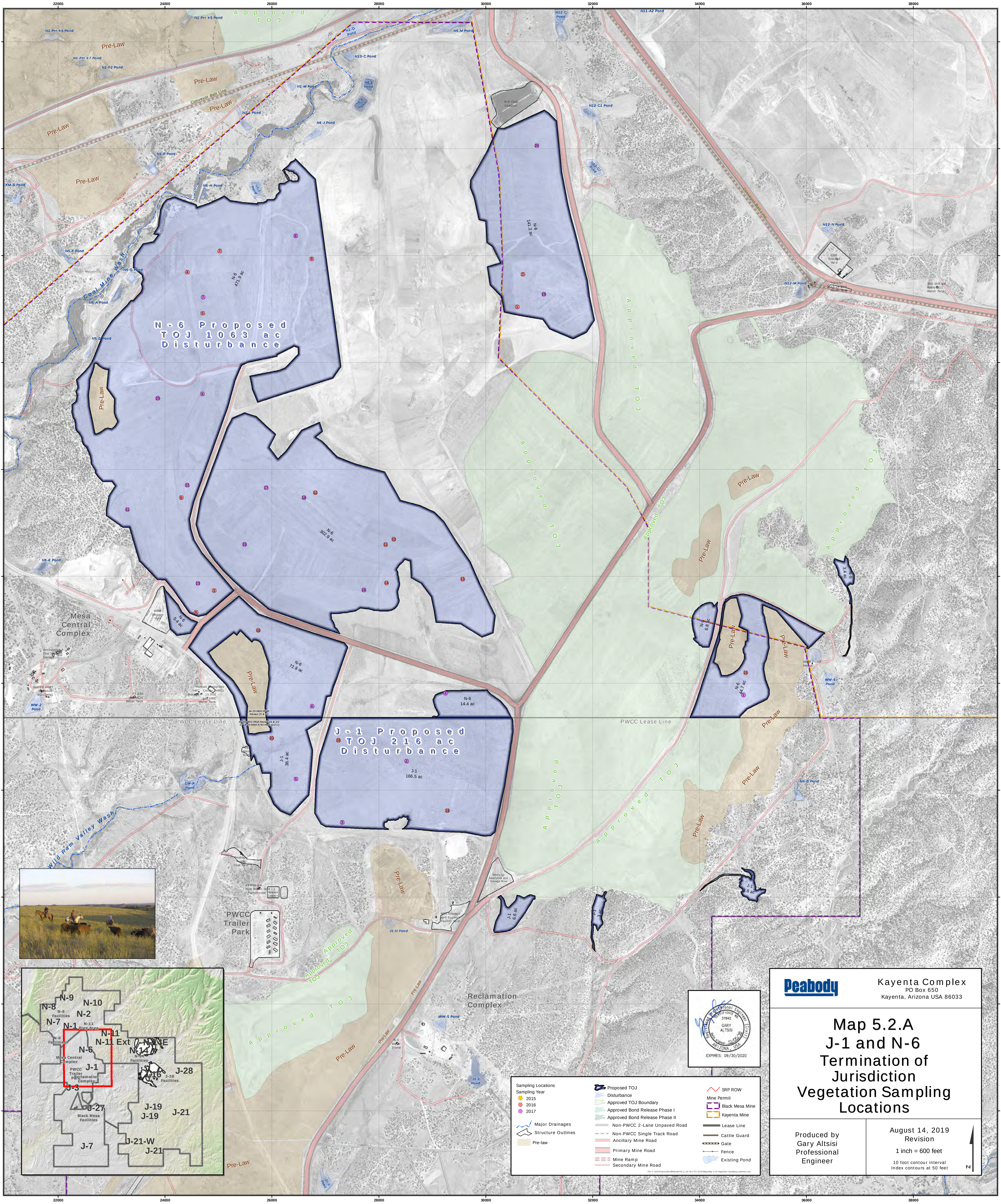

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Map 5.2.A
J-1 and N-6
Termination of Jurisdiction Vegetation Sampling Locations

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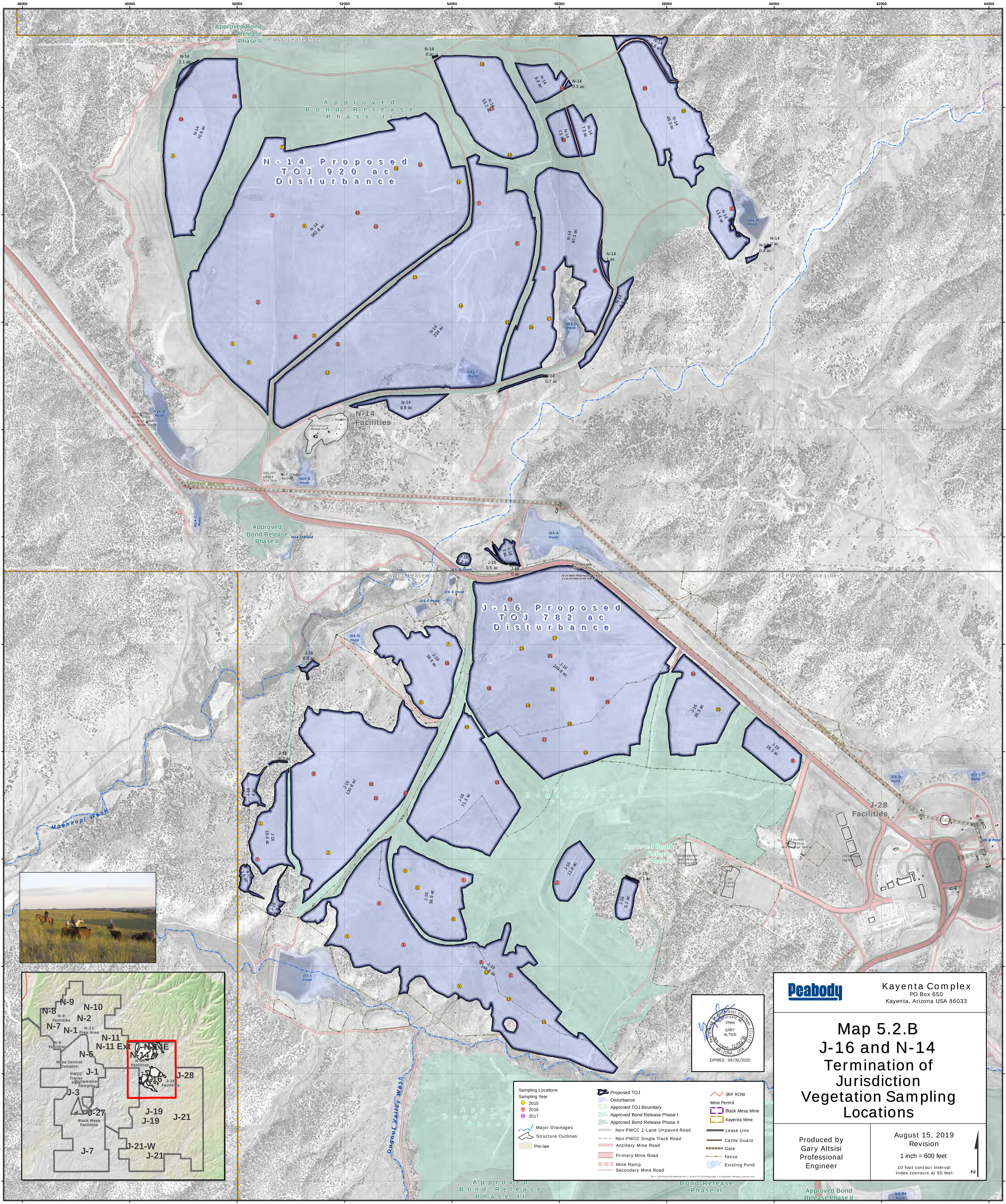
Index contours at 50 feet



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Sampling Locations
Sampling Year
● 2015
● 2016
● 2017

Major Drainages
Structure Outlines
Pre-law

Proposed TOJ
Disturbance
Approved TOJ Boundary
Approved Bond Release Phase I
Approved Bond Release Phase II
Non-PWCC 2-Lane Unpaved Road
Non-PWCC Single Track Road
Ancillary Mine Road
Primary Mine Road
Mine Ramp
Secondary Mine Road

SRP ROW
Mine Permit
Black Mesa Mine
Kayenta Mine
Lease Line
Cattle Guard
Gate
Fence
Existing Pond

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Map 5.2.B
J-16 and N-14
Termination of Jurisdiction Vegetation Sampling Locations

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Index contours at 50 feet

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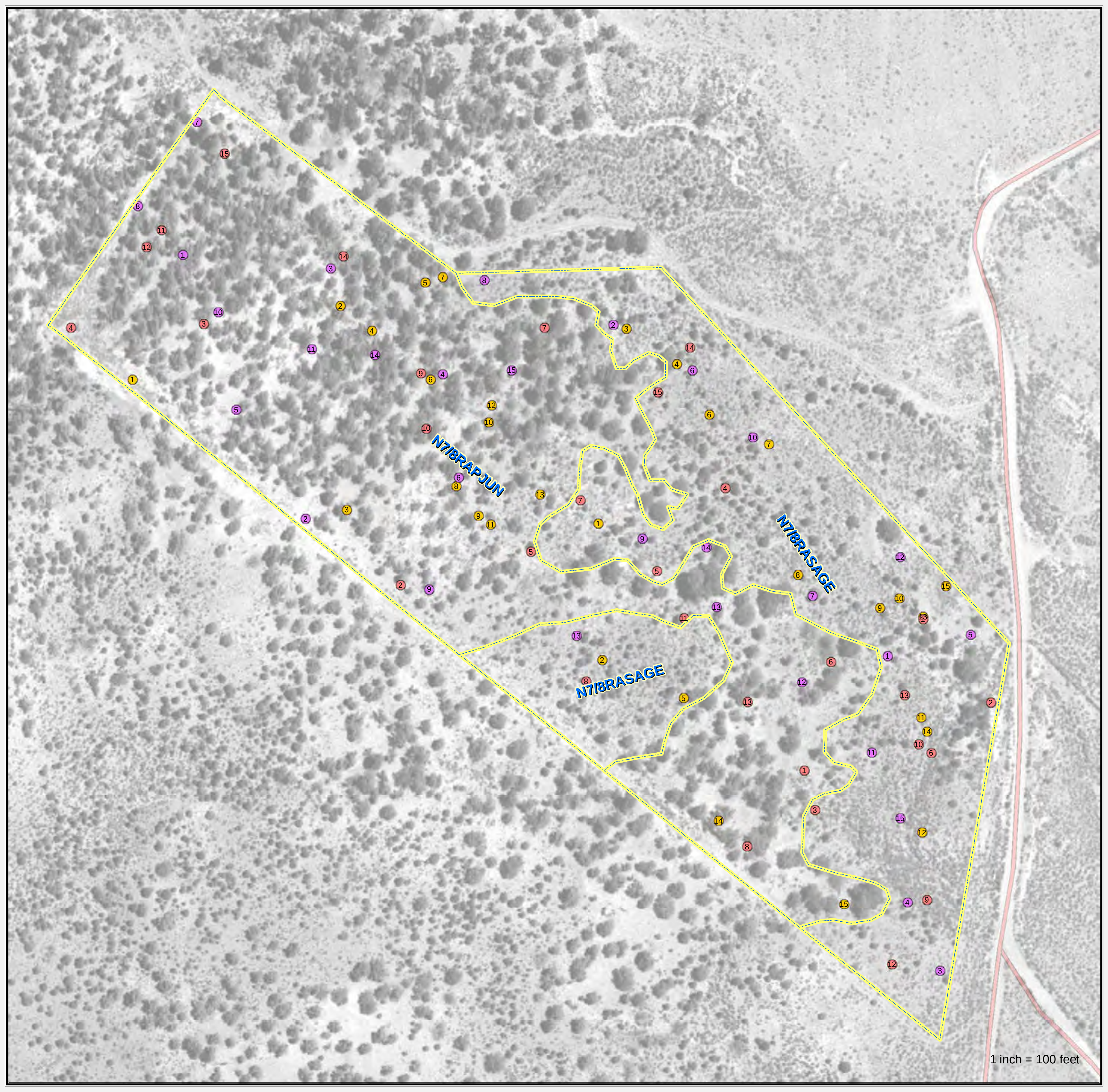

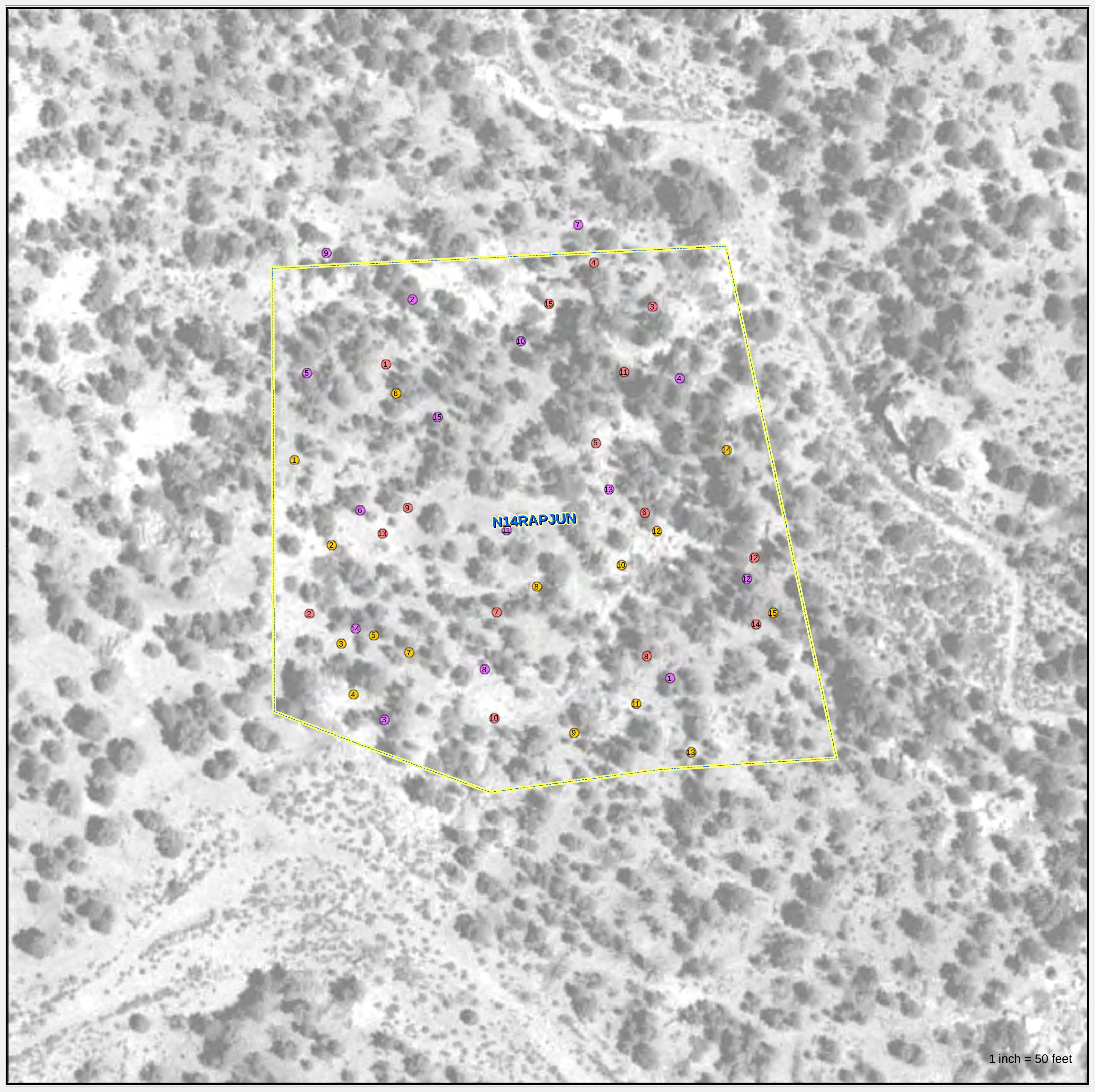

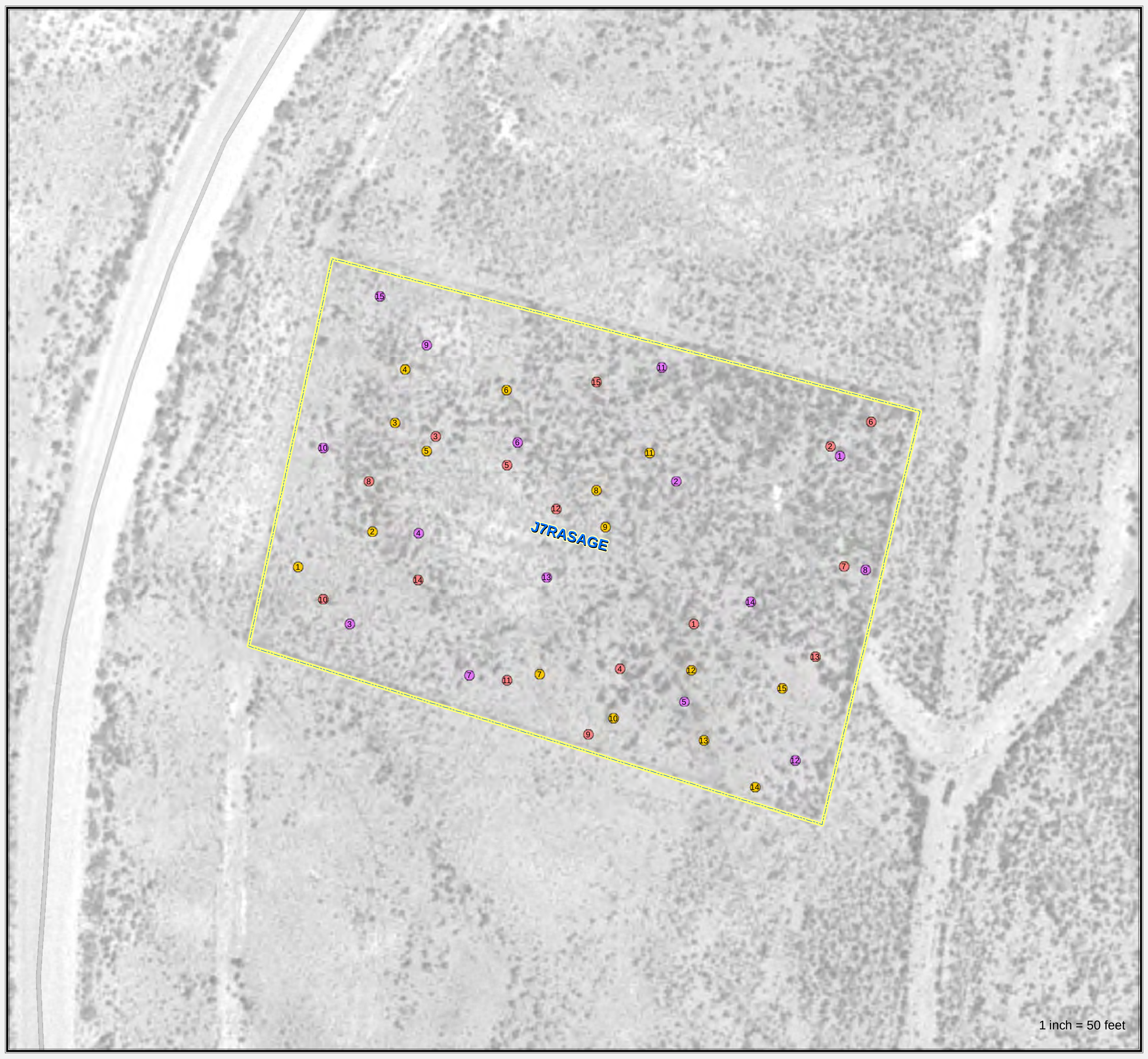

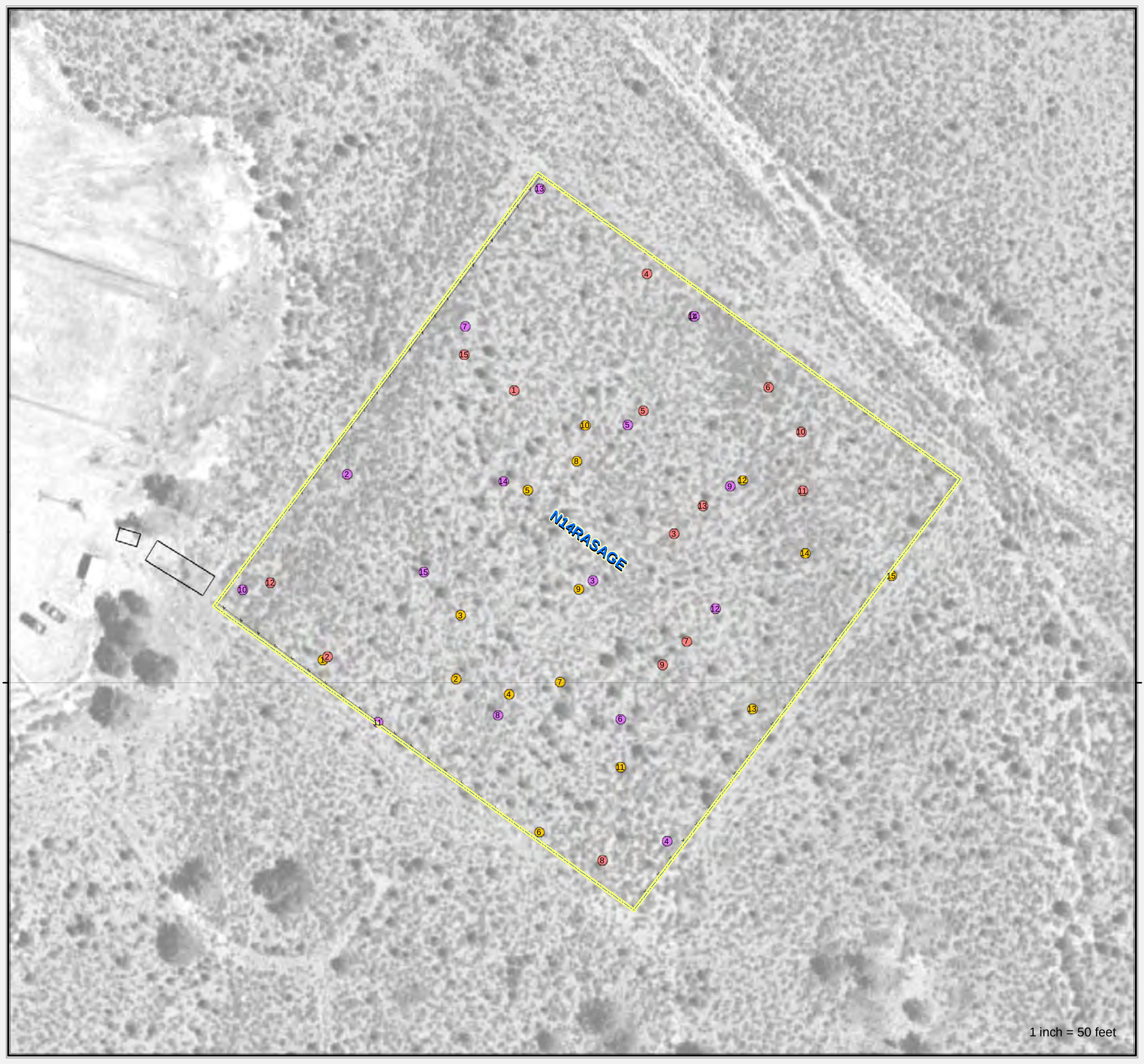

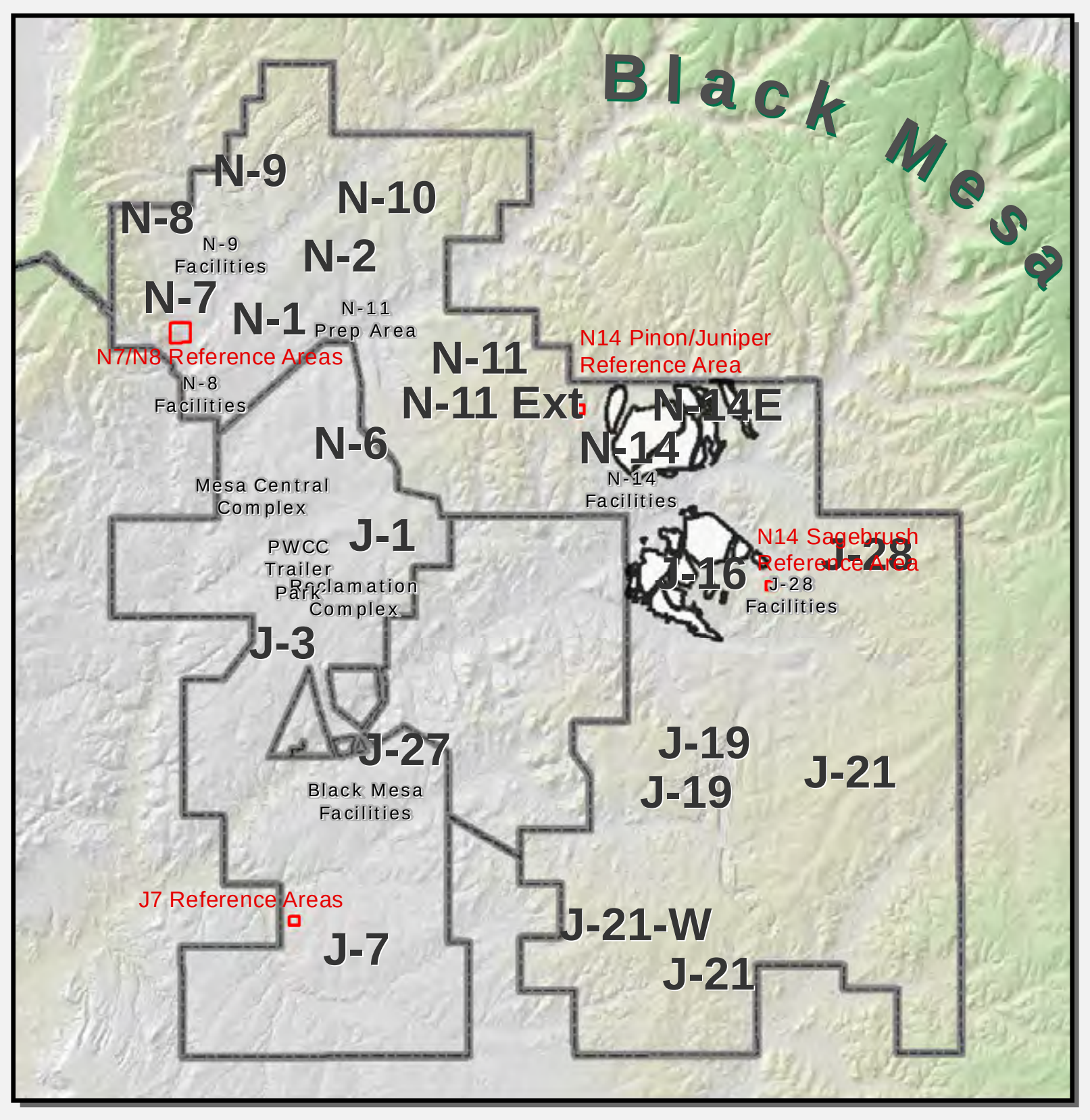

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EXPIRES: 09/30/2020

Sampling Locations
Sampling Year
● 2015
● 2016
● 2017

Major Drainages
Structure Outlines

Reference Area

Non-PWCC 2-Lane Unpaved Road
Non-PWCC Single Track Road
Ancillary Mine Road
Primary Mine Road
Mine Ramp
Secondary Mine Road

Lease Line
Cattle Guard
Gate
Fence
Existing Pond

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Map 5.2.C
Reference Areas Termination of Jurisdiction Vegetation Sampling Locations

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2015 J-16 Cover Data Summary and Raw Data

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																																							
						1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE ANNUAL & BIENNIAL FORBS																																													
Chenopodium graveolens	0.00	5.00	0.00	0.00	0.00																																							P	
Chenopodium leptophyllum	0.00	5.00	0.00	0.00	0.00	P																																							
Conyza canadensis	0.00	15.00	0.00	0.00	0.00																									P		P								P					
Descurainia pinnata	0.00	5.00	0.00	0.00	0.00	P																																							
Dyssodia papposa	0.00	5.00	0.00	0.00	0.00									P																															
Euphorbia serrula	0.00	15.00	0.00	0.00	0.00	P																								P						P									
Lappula redowskii	0.00	10.00	0.00	0.00	0.00																																	P		P					
Machaeranthera canescens	0.15	35.00	0.43	0.20	0.56	2	1																							P		P				P		1		P				P	
TOTAL NATIVE ANN. & BIEN. FORBS	0.15	40.00	0.43	0.20	0.56	2	1							P																P		P				P		1		P				P	
INTRODUCED ANNUAL & BIENNIAL FORBS																																													
Halogeton glomeratus	0.00	5.00	0.00	0.00	0.00	P																																							
Kochia scoparia	0.40	30.00	1.16	0.45	1.25					P				P														3	1	3				P				2							
Salsola iberica	0.00	10.00	0.00	0.00	0.00	P																																P							
Sisymbrium altissimum	0.00	5.00	0.00	0.00	0.00																																	P							
Tragopogon dubius	0.00	25.00	0.00	0.00	0.00																									P		P				P				P				P	
TOTAL INTRO. ANN. & BIEN. FORBS	0.40	55.00	1.16	0.45	1.25	P				P				P														3	1	3		P		P		P		2		P				P	
NATIVE ANNUAL GRASSES																																													
Munroa squarrosa	0.00	10.00	0.00	0.00	0.00																									P								P							
TOTAL NATIVE ANNUAL GRASSES	0.00	10.00	0.00	0.00	0.00																									P								P							
NATIVE PERENNIAL FORBS																																													
Leucelene ericoides	0.00	5.00	0.00	0.00	0.00	P																																							
Penstemon sp.	0.00	5.00	0.00	0.00	0.00																											P													
Ratibida columnaris	0.00	5.00	0.00	0.00	0.00																									P															
Sphaeralcea coccinea	0.05	15.00	0.14	0.05	0.14																															1		P						P	
Viguiera multiflora	0.00	10.00	0.00	0.00	0.00	P																										P													
TOTAL NATIVE PERENNIAL FORBS	0.05	30.00	0.14	0.05	0.14	P																								P		P				1		P						P	
NATIVE PERENNIAL GRASSES (cool)																																													
Agropyron smithii	1.90	40.00	5.51	2.05	5.71	3	3							9																1		7				9		4		P				5	
Agropyron spicatum	0.00	5.00	0.00	0.00	0.00																											P													
Agropyron trachycaulum	0.20	15.00	0.58	0.20	0.56	1																										3						P							
Oryzopsis hymenoides	0.20	30.00	0.58	0.25	0.70									P										P						P		1	1			2		1							
Sitanion hystrix	0.05	5.00	0.14	0.05	0.14																																					1			
Stipa comata	0.00	5.00	0.00	0.00	0.00																																							P	
TOTAL NATIVE PERENNIAL GRASSES (c)	2.35	50.00	6.81	2.55	7.10	4	3							9										P						1		11	1			11		5		P		1		5	
NATIVE PERENNIAL GRASSES (warm)																																													
Aristida purpurea	0.00	5.00	0.00	0.00	0.00																									P															
Bouteloua curtipendula	0.20	15.00	0.58	0.20	0.56																									1		3				P									
Bouteloua gracilis	1.00	40.00	2.90	1.00	2.79											P														2		P				2		P		1		10		5	
Buchloe dactyloides	0.05	5.00	0.14	0.05	0.14																																	1							
Hilaria jamesii	0.55	40.00	1.59	0.60	1.67											1				P										4		P				3		2	1	P				1	
Sporobolus airoides	5.55	40.00	16.09	5.65	15.74											18												3	1			8		6		19	1			13		10		34	
Sporobolus cryptandrus	0.25	30.00	0.72	0.25	0.70																			P		1				P		1				3								P	
TOTAL NATIVE PERENNIAL GRASSES (w)	7.60	65.00	22.03	7.75	21.59											19				P				P		1		3	1	7		12		6		27	1	3	1	14		20		40	
INTRODUCED PERENNIAL GRASSES (cool)																																													
Agropyron intermedium	0.05	5.00	0.14	0.05	0.14																															1									
Bromus inermis	0.00	20.00	0.00	0.00	0.00									P																P		P				P									
Elymus junceus	18.25	90.00	52.90	18.95	52.79	9	3	26	2	28		23		18		14		32		30	1	32		24	2	14		20	3	15	1			28	2			26		18		7		1	
TOTAL INTRO. PERENNIAL GRASSES (c)	18.30	100.00	53.04	19.00	52.92	9	3	26	2	28		23		18		14		32		30	1	32		24	2	14		20	3	15	1	P		28	2	1		26		18		7		1	
NATIVE SUBSHRUBS																																													
Ceratoides lanata	0.00	10.00	0.00	0.00	0.00																									P								P							
Gutierrezia sarothrae	0.45	35.00	1.30	0.50	1.39	1	1									1														P		6				1				P				P	
Senecio douglasii var. longilobus	0.00	5.00	0.00	0.00	0.00																															P									
TOTAL NATIVE SUBSHRUBS	0.45	40.00	1.30	0.50	1.39	1	1									1														P		6				1		P		P				P	
INTRODUCED SUBSHRUBS																																													
Kochia prostrata	1.30	25.00	3.77	1.45	4.04	6	1									2														5								1	1			12	1		
TOTAL INTRO. SUBSHRUBS	1.30	25.00	3.77	1.45	4.04	6	1									2														5								1	1			12	1		
NATIVE SHRUBS																																													
Atriplex canescens	3.75	90.00	10.87	3.75	10.45	18		4		1		P		P		3		P		2		P		5				10		4		3		9		5		2				P		9	
Atriplex confertifolia	0.05	30.00	0.14	0.05	0.14					P		P		1						P						P														P					
Chrysothamnus nauseosus	0.05	10.00	0.14	0.05	0.14	1										P																													

2015 J-16 Cover Data Summary and Raw Data

TOTAL NATIVE SHRUBS	3.85	100.00	11.16	3.85	10.72	19	4	1	P	1	3	P	2	P	5	P	10	4	3	9	5	2	P	P	9
Standing dead	3.00	80.00		3.00		3		6	5	3			4	8	3	3	1	2	2		6	1	6	5	2
Litter	11.55	100.00		11.55		7	9	8	7	8	4	10	8	9	8	13	10	61	13	6	15	8	8	5	14
Bare ground	48.40	100.00		48.40		49	59	50	59	57	56	58	52	45	59	61	46	2	53	48	32	51	52	50	29
Rock	2.55	65.00		2.55			2	7	6	3	1		4	6	1	8	7			3	1		2		
TOTALS	100.00		100.00	101.40	100.00	100 9	100 2	100 0	100 0	100 1	100 0	100 0	100 1	100 0	100 2	100 0	100 5	100 1	100 1	100 2	100 1	100 2	100 0	100 1	100 0
TOTAL VEGETATION COVER	34.50	s=(8.6)		35.90	s=(9.34)	41 9	30 2	29 0	23 0	29 1	39 0	32 0	32 1	32 0	29 2	15 0	36 5	35 1	32 1	43 2	46 1	40 2	32 0	40 1	55 0
GROUND COVER (Veg+Litter+St.Dead+Rock)	51.60	s=(13.75)		53.00	s=(13.94)	51 9	41 2	50 0	41 0	43 1	44 0	42 0	48 1	55 0	41 2	39 0	54 5	98 1	47 1	52 2	68 1	49 2	48 0	50 1	71 0
SPECIES DENSITY (# of species/100 sq.m.)	8.20	s=(6.05)				15	2	4	3	9	8	2	4	2	4	3	4	20	17	4	16	17	11	6	13

2015 N-14 Cover Summary and Raw Data

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																																							
						1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE ANNUAL & BIENNIAL FORBS						Data Removed Due to Boundary Change		Data Removed Due to Boundary Change		Data Removed Due to Boundary Change																																			
Ambrosia acanthicarpa	0.12	5.88	0.38	0.12	0.36																													2											
Bahia dissecta	0.00	0.00	0.00	0.00	0.00																																								
Chaenactis stevioides	0.24	5.88	0.76	0.35	1.08																													4	2										
Chenopodium leptophyllum	0.00	23.53	0.00	0.00	0.00									P										P				P																P	
Conyza canadensis	0.00	11.76	0.00	0.00	0.00																	P																P							
Euphorbia serrula	0.00	17.65	0.00	0.00	0.00									P								P								P															
Ipomopsis longiflora	0.00	5.88	0.00	0.00	0.00																													P											
Lappula redowskii	0.00	5.88	0.00	0.00	0.00																																	P							
Machaeranthera canescens	0.00	11.76	0.00	0.00	0.00															P														P											
Verbesina enceloides	0.00	5.88	0.00	0.00	0.00																									P															
TOTAL NATIVE ANN. & BIEN. FORBS	0.35	52.94	1.15	0.47	1.45									P						P		P		P				P		P				6	2			P						P	
INTRODUCED ANNUAL & BIENNIAL FORBS																																													
Kochia scoparia	0.00	17.65	0.00	0.00	0.00							P										P																P							
Lactuca serriola	0.00	17.65	0.00	0.00	0.00																					P								P										P	
Melilotus officinalis	0.00	5.88	0.00	0.00	0.00							P																																	
Polygonum aviculare	0.00	5.88	0.00	0.00	0.00																																							P	
Salsola iberica	0.00	5.88	0.00	0.00	0.00																									P															
Tragopogon dubius	0.00	0.00	0.00	0.00	0.00																																								
TOTAL INTRO. ANN. & BIEN. FORBS	0.00	41.18	0.00	0.00	0.00							P										P				P				P				P				P						P	
NATIVE ANNUAL GRASSES																																													
Munroa squarrosa	0.00	23.53	0.00	0.00	0.00											P						P				P		P																	
TOTAL NATIVE ANNUAL GRASSES	0.00	23.53	0.00	0.00	0.00											P						P				P		P																	
NATIVE PERENNIAL FORBS																																													
Ambrosia psilostachya	0.00	5.88	0.00	0.00	0.00																					P																			
Astragalus praelongus	0.00	5.88	0.00	0.00	0.00																					P																			
Astragalus sp.	0.00	11.76	0.00	0.00	0.00															P				P																					
Erigeron concinnus	0.00	5.88	0.00	0.00	0.00																							P																	
Gilia aggregata	0.00	5.88	0.00	0.00	0.00																	P																							
Leucelene ericoides	0.00	11.76	0.00	0.00	0.00																							P						P											
Penstemon palmeri	0.00	5.88	0.00	0.00	0.00																																							P	
Ratibida columnaris	0.00	11.76	0.00	0.00	0.00																									P				P											
Sphaeralcea ambigua	0.06	11.76	0.19	0.06	0.18							P																																1	
TOTAL NATIVE PERENNIAL FORBS	0.06	52.94	0.19	0.06	0.18							P								P		P		P		P		P		P				P										1	
NATIVE PERENNIAL GRASSES (cool)																																													
Agropyron smithii	2.18	70.59	7.06	2.35	7.23							P								6		5		5		3		9	1	3	2	P		4		P				P				2	
Agropyron spicatum	0.18	23.53	0.57	0.24	0.72																							1		1	1	P		1											
Agropyron trachycaulum	0.12	5.88	0.38	0.12	0.36																																							2	
Oryzopsis hymenoides	0.18	52.94	0.57	0.18	0.54									P		P				P						P		P						3				P		P				P	
TOTAL NATIVE PERENNIAL GRASSES (c)	2.65	88.24	8.59	2.88	8.86							P		P		P				6		5		5		3		10	1	4	3	P		8		P		P		P				4	
NATIVE PERENNIAL GRASSES (warm)																																													
Aristida purpurea	0.06	5.88	0.19	0.06	0.18																													1											
Bouteloua curtipendula	0.41	11.76	1.34	0.41	1.27																											1												6	
Bouteloua gracilis	1.65	35.29	5.34	1.71	5.24																							2		13	1	P		1		1								11	
Hilaria jamesii	1.47	64.71	4.77	1.59	4.88							P		1								1		P		1		8		4	1			1		2				P				7	1
Sporobolus airoides	0.94	29.41	3.05	0.94	2.89																	3						7		2						1								3	
Sporobolus cryptandrus	1.29	47.06	4.20	1.35	4.16							P		P								3				P		15		1				3	1									P	
TOTAL NATIVE PERENNIAL GRASSES (w)	5.82	70.59	18.89	6.06	18.63							P		1								7		P		1		32		20	2	1		6	1	4				P				27	1
INTRODUCED PERENNIAL GRASSES (cool)																																													
Agropyron desertorum	0.59	29.41	1.91	0.59	1.81									1		2												P						4				3							
Agropyron intermedium	0.06	11.76	0.19	0.06	0.18																													1						P					
Bromus inermis	0.00	11.76	0.00	0.00	0.00																					P								P											
Elymus junceus	14.65	94.12	47.52	15.65	48.10							22	1	22	1	25		20	4	16	4	13		14		13		6	1	11		17				16	1	16	1	15	1	13	3	10	
TOTAL INTRO. PERENNIAL GRASSES (c)	15.29	100.00	49.62	16.29	50.09							22	1	23	1	27		20	4	16	4	13		14		13		6	1	11		17		5		16	1	19	1	15	1	13	3	10	
NATIVE SUBSHRUBS																																													
Ceratoides lanata	0.00	47.06	0.00	0.00	0.00													P		P						P		P		P				P		P								P	
Gutierrezia sarothrae	0.12	17.65	0.38	0.12	0.36																	1				P		1																	
Senecio douglasii var. longilobus	0.00	17.65	0.00	0.00	0.00															P												P		P											
TOTAL NATIVE SUBSHRUBS	0.12	58.82	0.38	0.12	0.36													P		P		1				P		1		P		P		P		P								P	
INTRODUCED SUBSHRUBS																																													
Kochia prostrata	2.47	41.18	8.02	2.47	7.59							P						3																P		10				16		11		2	

2015 N-14 Cover Summary and Raw Data

TOTAL INTRO. SUBSHRUBS FORBS	2.47	41.18	8.02	2.47	7.59			P			3								P	10		16	11	2
NATIVE SHRUBS																								
Atriplex canescens	3.47	100.00	11.26	3.59	11.03			1	4 1	4 1	5	11	2	2	3	5	4	P	5	2	6	P	5	P
Atriplex confertifolia	0.00	11.76	0.00	0.00	0.00							P												P
Chrysothamnus nauseosus	0.59	11.76	1.91	0.59	1.81														10		P			
Chrysothamnus viscidiflorus	0.00	5.88	0.00	0.00	0.00											P								
TOTAL NATIVE SHRUBS	4.06	100.00	13.17	4.18	12.84			1	4 1	4 1	5	11	2	2	3	5	4	P	15	2	6	P	5	P
LICHEN/FUNGUS																								
Lichen	0.00	0.00	0.00	0.00	0.00																			
Mushroom	0.00	0.00	0.00	0.00	0.00																			
TOTAL LICHEN	0.00	0.00	0.00	0.00	0.00																			
Standing dead	1.35	47.06		1.35							6	2	3	5	4		1			1	1			
Litter	11.35	100.00		11.35				6	9	12	14	7	9	6	15	17	13	18	15	16	5	8	14	9
Bare ground	50.12	100.00		50.12				64	63	55	51	53	59	63	61	28	40	40	44	45	63	45	43	35
Rock	6.35	88.24		6.35				7		2	1	5	1	5		1	7	24	1	6	6	16	14	12
TOTALS	100.00		100.00	101.71	100.00			100 1	100 2	100 1	100 4	100 4	100 0	100 0	100 0	100 2	100 5	100 0	100 3	100 1	100 1	100 1	100 3	100 1
TOTAL VEGETATION COVER	30.82	s=(9.25)		32.53	s=(10.04)			23 1	28 2	31 1	28 4	33 4	28 0	21 0	20 0	54 2	39 5	18 0	40 3	32 1	25 1	31 1	29 3	44 1
GROUND COVER (Veg+Litter+St.Dead+Rock)	49.88	s=(11.13)		51.59	s=(11.72)			36 1	37 2	45 1	49 4	47 4	41 0	37 0	39 0	72 2	60 5	60 0	56 3	55 1	37 1	55 1	57 3	65 1
SPECIES DENSITY (# of species/100 sq.m.)	15.71	s=(6.49)						15	15	10	8	14	20	11	19	23	20	11	31	12	15	11	7	25

2016 J-16 Cover Summary and Raw Data

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																																									
						1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20		21	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE ANNUAL & BIENNIAL FORBS																																															
Euphorbia serpyllifolia	0.00	4.76	0.00	0.00	0.00													P																													
Machaeranthera canescens	0.00	14.29	0.00	0.00	0.00																																			P		P				P	
TOTAL NATIVE ANN. & BIEN. FORBS	0.00	19.05	0.00	0.00	0.00													P																						P		P				P	
INTRODUCED ANNUAL & BIENNIAL FORBS																																															
Melilotus officinalis	0.05	14.29	0.16	0.05	0.15																																			P				1		P	
TOTAL INTRO. ANN. & BIEN. FORBS	0.05	14.29	0.16	0.05	0.15																																			P				1		P	
INTRODUCED ANNUAL GRASSES																																															
Bromus tectorum	0.00	4.76	0.00	0.05	0.15																															P	1										
TOTAL INTRODUCED ANNUAL GRASSES	0.00	4.76	0.00	0.05	0.15																															P	1										
NATIVE PERENNIAL GRASSES (cool)																																															
Agropyron smithii	1.81	38.10	6.13	1.86	5.82			3						P				3																		2				5		13	1	3		9	
Hilaria jamesii	0.90	57.14	3.06	1.05	3.28			P						P				P		5				1		P		1				6	1			1				1	1	4				P	1
Oryzopsis hymenoides	0.10	4.76	0.32	0.10	0.30																																									2	
TOTAL NATIVE PERENNIAL GRASSES (c)	2.81	61.90	9.52	3.00	9.40			3						P				3		5				1		P		1				6	1			3				6	1	17	1	3		11	1
NATIVE PERENNIAL GRASSES (warm)																																															
Bouteloua curtipendula	0.00	4.76	0.00	0.00	0.00																																					P					
Bouteloua gracilis	4.38	52.38	14.84	4.57	14.33	5		2						P				1		21								1		22	2	25	2			P		5				10					
Sporobolus airoides	4.90	71.43	16.61	4.95	15.52	18		P								P				4				1		4		7		5		18				15	1	6		2		3		6		14	
TOTAL NATIVE PERENNIAL GRASSES (w)	9.29	80.95	31.45	9.52	29.85	23		2						P		P		1		25				1		4		8		27	2	43	2			15	1	11		2		13		6		14	
INTRODUCED PERENNIAL GRASSES (cool)																																															
Agropyron intermedium	0.05	4.76	0.16	0.05	0.15																																			1							
Bromus inermis	0.00	4.76	0.00	0.00	0.00																																					P					
Elymus junceus	11.43	100.00	38.71	12.57	39.40	3		19	1	15	2	15		16	4	10	1	16	6	8		12		18		13		8	2	6	1	2		22		11	5	6		18	1	1		16		5	1
TOTAL INTRO. PERENNIAL GRASSES (c)	11.48	100.00	38.87	12.62	39.55	3		19	1	15	2	15		16	4	10	1	16	6	8		12		18		13		8	2	6	1	2		22		11	5	6		19	1	1		16		5	1
NATIVE SUBSHRUBS																																															
Ceratoides lanata	0.00	9.52	0.00	0.00	0.00																															P				P							
Gutierrezia sarothrae	0.29	19.05	0.97	0.33	1.04													2																		P						P				4	1
TOTAL NATIVE SUBSHRUBS	0.29	23.81	0.97	0.33	1.04													2																		P				P		P				4	1
INTRODUCED SUBSHRUBS																																															
Kochia prostrata	1.71	19.05	5.81	2.38	7.46	14	6															5								7	6							10	2								
TOTAL INTRO. SUBSHRUBS FORBS	1.71	19.05	5.81	2.38	7.46	14	6															5								7	6							10	2								
NATIVE SHRUBS																																															
Artemisia tridentata	0.00	19.05	0.00	0.00	0.00											P		P										P														P					
Atriplex canescens	3.86	85.71	13.06	3.90	12.24	P		4		5		4		11		8		12		P		4		P		5		5				5				13				1		2	1	P		2	
Chrysothamnus nauseosus	0.05	9.52	0.16	0.05	0.15																																			P		1					
TOTAL NATIVE SHRUBS	3.90	85.71	13.23	3.95	12.39	P		4		5		4		11		8		12		P		4		P		5		5				5				13				1		3	1	P		2	
AGAVOIDS																																															
Yucca angustissima	0.00	4.76	0.00	0.00	0.00													P																													
TOTAL AGAVOIDS	0.00	4.76	0.00	0.00	0.00													P																													
Standing dead	0.29	9.52		0.29																3												3															
Litter	8.67	100.00		8.67		3		16		5		6		7		8		8		7		8		13		9		11		5		10		10		13		3		9		17		8		6	
Bare ground	55.62	95.24		55.62		53				75		72		65		65		57		48		66		55		60		62		55		30		65		41		68		58		49		66		58	
Rock	3.38	76.19		3.38		4		3				3		1		9		1		4		5		12		9		5				1		3		4		2		5							
TOTALS	97.48		100.00	99.86	100.00	100	6	47	1	100	2	100	0	100	4	100	1	100	6	100	0	100	0	100	0	100	0	100	2	100	9	100	3	100	0	100	7	100	2	100	2	100	2	100	0	100	3
TOTAL VEGETATION COVER	29.52	s=(9.82)		31.90	s=(11.61)	40	6	28	1	20	2	19	0	27	4	18	1	34	6	38	0	21	0	20	0	22	0	22	2	40	9	56	3	22	0	42	7	27	2	28	2	34	2	26	0	36	3
GROUND COVER (Veg+Litter+St.Dead+Rock)	41.86	s=(10.49)		44.24	s=(11.7)	47	6	47	1	25	2	28	0	35	4	35	1	43	6	52	0	34	0	45	0	40	0	38	2	45	9	70	3	35	0	59	7	32	2	42	2	51	2	34	0	42	3
SPECIES DENSITY (# of species/100 sq.m.)	5.43	s=(2.86)				5		6		2		2		5		4		9		5		3		4		4		6		4		5		1		9		4		10		12		5		9	

2016 N6-J1 Cover Data Summary and Raw Data

	AVERAGE COVER	FREQUENCY	RELATIVE VEGETATION COVER	AVERAGE COVER-ALL	RELATIVE VEGETATION COVER-ALL	Percent Foliar Cover																																		
PLANT SPECIES	(%)	(%)	(%)	(%)	(%)	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE ANNUAL & BIENNIAL FORBS																																						Data Removed Due to Boundary Change							
Euphorbia serpyllifolia	0.00	15.79	0.00	0.00	0.00							P										P																						P	
Machaeranthera canescens	0.00	10.53	0.00	0.00	0.00									P																P															
TOTAL NATIVE ANN. & BIEN. FORBS	0.00	26.32	0.00	0.00	0.00							P		P								P								P														P	
INTRODUCED ANNUAL & BIENNIAL FORBS																																													
Kochia scoparia	0.00	5.26	0.00	0.00	0.00																	P																							
Melilotus officinalis	0.00	10.53	0.00	0.00	0.00							P		P																															
TOTAL INTRO. ANN. & BIEN. FORBS	0.00	15.79	0.00	0.00	0.00							P		P								P																							
NATIVE ANNUAL GRASSES																																													
Bouteloua barbata	0.05	5.26	0.16	0.05	0.15																	1																							
Festuca octoflora	0.00	5.26	0.00	0.00	0.00							P																																	
Monroa squarrosa	0.00	5.26	0.00	0.00	0.00																																							P	
TOTAL NATIVE ANNUAL GRASSES	0.05	15.79	0.16	0.05	0.15							P										1																						P	
NATIVE PERENNIAL FORBS																																													
Gaillardia aristata	0.00	5.26	0.00	0.00	0.00									P																															
Linum lewisii	0.00	5.26	0.00	0.00	0.00									P																															
Penstemon sp.	0.05	10.53	0.16	0.05	0.15							1		P																															
Sphaeralcea coccinea	0.05	5.26	0.16	0.05	0.15																																							1	
TOTAL NATIVE PERENNIAL FORBS	0.11	15.79	0.32	0.11	0.30							1		P																														1	
INTRODUCED PERENNIAL FORBS																																													
Sanguisorba minor	0.00	5.26	0.00	0.00	0.00									P																															
TOTAL INTRO. PERENNIAL FORBS	0.00	5.26	0.00	0.00	0.00									P																															
NATIVE PERENNIAL GRASSES (cool)																																													
Agropyron smithii	2.79	52.63	8.41	2.95	8.27	11		1				7		16	1							P		10	1					3		P								2			1	3	
Hilaria jamesii	1.68	57.89	5.08	1.74	4.87	5				1				2		1		3				3	1	2		1				3		8								3					
Oryzopsis hymenoides	0.26	36.84	0.79	0.26	0.74	2				1		P		P				P				P																				2			
Stipa comata	0.00	5.26	0.00	0.05	0.15																																			P	1				
TOTAL NATIVE PERENNIAL GRASSES (c)	4.74	78.95	14.29	5.00	14.03	18		1		2		7		18	1	1		3				3	1	12	1	1				6		8								5	1	2	1	3	
NATIVE PERENNIAL GRASSES (warm)																																													
Aristida purpurea	0.00	5.26	0.00	0.00	0.00																																							P	
Bouteloua curtipendula	0.42	26.32	1.27	0.42	1.18							3		2				P				2																				1			
Bouteloua gracilis	2.74	52.63	8.25	2.79	7.83	11				4				2		8		1				10				P						3								7		6	1		
Sporobolus airoides	2.21	47.37	6.67	2.53	7.09					3						P						10	2			2						1		P						19	3	1		6	1
TOTAL NATIVE PERENNIAL GRASSES (w)	5.37	68.42	16.19	5.74	16.10	11				7		3		4		8		1				22	2			2						4		P						26	3	8	1	6	1
INTRODUCED PERENNIAL GRASSES (cool)																																													
Agropyron desertorum	0.16	5.26	0.48	0.16	0.44																													3											
Agropyron intermedium	0.00	5.26	0.00	0.00	0.00																													P											
Bromus inermis	0.00	10.53	0.00	0.00	0.00																																			P				P	
Elymus junceus	15.42	100.00	46.51	17.16	48.15	10	1	22	2	18	6	15	1	4	1	19		9	6	23	3	8		6	2	13	3	24		15		18	2	21	1	34	3			7		14		13	2
TOTAL INTRO. PERENNIAL GRASSES (c)	15.58	100.00	46.98	17.32	48.60	10	1	22	2	18	6	15	1	4	1	19		9	6	23	3	8		6	2	13	3	24		15		18	2	24	1	34	3			7		14		13	2
NATIVE SUBSHRUBS																																													
Ceratoides lanata	0.05	26.32	0.16	0.05	0.15	P								P				P		1																						P			
Gutierrezia sarothrae	0.32	52.63	0.95	0.32	0.89	3		P						1		P		P						P		P				1										1				P	
Senecio douglasii var. longilobus	0.00	5.26	0.00	0.00	0.00									P																															
TOTAL NATIVE SUBSHRUBS	0.37	63.16	1.11	0.37	1.03	3		P						1		P		P		1				P		P				1										1		P		P	
INTRODUCED SUBSHRUBS																																													
Kochia prostrata	1.58	26.32	4.76	1.68	4.73									2	2	5		20		1								2																	
TOTAL INTRO. SUBSHRUBS FORBS	1.58	26.32	4.76	1.68	4.73									2	2	5		20		1								2																	
NATIVE SHRUBS																																													
Artemisia tridentata	0.47	10.53	1.43	0.47	1.33																																			7				2	
Atriplex canescens	4.53	100.00	13.65	4.53	12.70	1		4		13		2		3		P		13		8		2		6		6		1		3		2		2		8				1		7		4	
Atriplex confertifolia	0.21	31.58	0.63	0.21	0.59									P		P		P						2		2						P													
Chrysothamnus nauseosus	0.11	15.79	0.32	0.11	0.30									P																										2				P	
Purshia tridentata	0.05	5.26	0.16	0.05	0.15									1																															
TOTAL NATIVE SHRUBS	5.37	100.00	16.19	5.37	15.07	1		4		13		2		4		P		13		8		2		8		8		1		3		2		2		8				10		7		6	
Standing dead	0.00	0.00		0.00																																									
Litter	11.89	100.00		11.89		10		5		7		10		9		4		12		11		17		19		11		9		11		7		14		5				8		37		20	
Bare ground	51.95	100.00		51.95		43		43		52		54		57		62		37		51		46		55		65		64		64		61		60		49				43		32		49	
Rock	3.00	57.89		3.00		4		25		1		8		1		1		5		5		1														4								2	
TOTALS	100.00		100.00	102.47	100.00	100	1	100	2	100	6	100	1	100	4	100	0	100	6	100	3	100	3	100	3	100	3	100	0	100	0	100	2	100	1	100	3			100	4	100	2	100	3
TOTAL VEGETATION COVER	33.16	s=(7.54)		35.63	s=(8.65)	43	1	27	2	40	6	28	1	33	4	33	0	46	6	33	3	36	3	26	3	24	3	27	0	25	0	32	2	26	1	42	3			49	4	31	2	29	3
GROUND COVER (Veg+Litter+St.Dead+Rock)	48.05	s=(9.61)		50.53	s=(10.51)	57	1	57	2	48	6	46	1	43	4	38	0	63	6	49	3	54	3	45	3	35	3	36	0	36	0	39	2	40	1	51	3			57	4	68	2	51	3
SPECIES DENSITY (# of species/100 sq.m.)	7.68	s=(4.07)				8		4		6		9		20		8		10		4		11		6		7		3		6		7		5		2				11		7		12	

2016 N-14 Cover Data Summary and Raw Data

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																																			
						1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE ANNUAL & BIENNIAL FORBS																																													
Bahia dissecta	0.00	5.56	0.00	0.00	0.00					P																																			
Conyza canadensis	0.06	5.56	0.18	0.06	0.17																					1																			
Cordylanthus wrightii	0.17	5.56	0.55	0.17	0.51			3																																					
Euphorbia glyptosperma	0.06	38.89	0.18	0.06	0.17					P						1		P										P						P		P		P							
Machaeranthera canescens	0.00	38.89	0.00	0.00	0.00	P		P		P						P		P								P								P											
Townsendia annua	0.00	5.56	0.00	0.00	0.00			P																																					
TOTAL NATIVE ANN. & BIEN. FORBS	0.28	55.56	0.91	0.28	0.85	P		3		P						1		P								1		P						P		P		P							
INTRODUCED ANNUAL & BIENNIAL FORBS																																													
Kochia scoparia	0.00	5.56	0.00	0.00	0.00					P																																			
Lactuca serriola	0.00	5.56	0.00	0.00	0.00																					P																			
Melilotus officinalis	0.06	16.67	0.18	0.06	0.17			P		1						P																													
Salsola iberica	0.06	5.56	0.18	0.06	0.17																					1																			
Sisymbrium altissimum	0.00	5.56	0.00	0.00	0.00																					P																			
Tragopogon dubius	0.00	5.56	0.00	0.00	0.00																																							P	
TOTAL INTRO. ANN. & BIEN. FORBS	0.11	27.78	0.37	0.11	0.34			P		1						P										1																		P	
NATIVE ANNUAL GRASSES																																													
Monroa squarrosa	0.00	22.22	0.00	0.00	0.00											P		P																		P								P	
TOTAL NATIVE ANNUAL GRASSES	0.00	22.22	0.00	0.00	0.00											P		P																		P								P	
NATIVE PERENNIAL FORBS																																													
Abronia elliptica	0.06	5.56	0.18	0.06	0.17			1																																					
Astragalus praelongus	0.00	5.56	0.00	0.00	0.00					P																																			
Gaillardia aristata	0.06	5.56	0.18	0.06	0.17																					1																			
Haplopappus spinulosus	0.00	5.56	0.00	0.00	0.00					P																																			
Penstemon palmeri	0.00	16.67	0.00	0.00	0.00			P										P																				P							
Ratibida columnaris	0.00	5.56	0.00	0.00	0.00					P																																			
TOTAL NATIVE PERENNIAL FORBS	0.11	27.78	0.37	0.11	0.34			1		P								P								1												P							
NATIVE PERENNIAL GRASSES (cool)																																													
Agropyron smithii	4.56	72.22	14.99	4.61	14.07	5		9		1						5		12		6		P		9		2		20	1					4				7		Data Removed Due to Boundary Change		Data Removed Due to Boundary Change		2	
Hilaria jamesii	2.06	33.33	6.76	2.06	6.27									1						17		2										2				2								13	
Oryzopsis hymenoides	0.44	38.89	1.46	0.44	1.36	P		4		1						P		2										1				P													
Sitanion hystrix	0.22	5.56	0.73	0.22	0.68																					4																			
TOTAL NATIVE PERENNIAL GRASSES (c)	7.28	88.89	23.95	7.33	22.37	5		13		2				1		5		14		23		2		9		6		21	1			2		4		2		7						15	
NATIVE PERENNIAL GRASSES (warm)																																													
Aristida purpurea	0.22	11.11	0.73	0.22	0.68			3								1																													
Bouteloua gracilis	0.33	27.78	1.10	0.33	1.02					1										1												P				P								4	
Sporobolus airoides	1.06	66.67	3.47	1.11	3.39			P		1								P		10		P		P		P		P				P	1	P		2								6	
TOTAL NATIVE PERENNIAL GRASSES (w)	1.61	72.22	5.30	1.67	5.08			3		2						1		P		11		P		P		P		P				P	1	P		2								10	
INTRODUCED PERENNIAL GRASSES (cool)																																													
Agropyron desertorum	0.06	11.11	0.18	0.06	0.17									P		1																													
Agropyron elongatum	0.00	5.56	0.00	0.00	0.00																					P																			
Agropyron intermedium	0.56	11.11	1.83	0.56	1.69											10																						P							
Bromus inermis	0.06	16.67	0.18	0.17	0.51			P								1	2	P																											
Elymus junceus	13.56	100.00	44.61	15.17	46.27	11	1	2		15		21	2	15	1	8	1	5	2	1		18		18	2	16	1	18	2	22	2	9	11	18	2	13	1	20	1					14	
TOTAL INTRO. PERENNIAL GRASSES (c)	14.22	100.00	46.80	15.94	48.64	11	1	2		15		21	2	15	1	20	3	5	2	1		18		18	2	16	1	18	2	22	2	9	11	18	2	13	1	20	1					14	
NATIVE SUBSHRUBS																																													
Gutierrezia sarothrae	1.00	38.89	3.29	1.22	3.73			P		1				P		3	1			12	2													1	1			1							
Senecio douglasii var. longilobus	0.00	16.67	0.00	0.00	0.00	P		P		P																																			
TOTAL NATIVE SUBSHRUBS	1.00	44.44	3.29	1.22	3.73	P		P		1				P		3	1			12	2													1	1			1							
INTRODUCED SUBSHRUBS																																													
Kochia prostrata	1.61	11.11	5.30	1.94	5.93																															28	6							1	
TOTAL INTRO. SUBSHRUBS FORBS	1.61	11.11	5.30	1.94	5.93																															28	6							1	
NATIVE SHRUBS																																													
Atriplex canescens	3.89	100.00	12.80	3.89	11.86	2		3		P		5		3		4		2		1		2		3		3		4		5		19		8		2		4						P	
Atriplex confertifolia	0.22	22.22	0.73	0.22	0.68	2		1																						P								1							
Chrysothamnus nauseosus	0.06	11.11	0.18	0.06	0.17			P										1																											
Sarcobatus vermiculatus	0.00	0.00	0.00	0.00	0.00																																								
TOTAL NATIVE SHRUBS	4.17	100.00	13.71	4.17	12.71	4		4		P		5		3		4		3		1		2		3		3		4		5		19		8		2		5						P	
Standing dead	0.00	0.00		0.00																																									
Litter	9.83	100.00		9.83		5		12		10		12		7		6		10		7		6		11		19		9		14		7		6		8		12						16	
Bare ground	55.72	100.00		55.72		73		61		55		44		74		60		68		45		72		57		51		48		48		51		61		44		50						41	
Rock	4.06	66.67		4.06		2		1		14		18												2		2				11		12		2		1		5						3	
TOTALS	100.00		100.00	102.39	100.00	100	1	100	0	100	0	100	2	100	1	100	4	100	2	100	2	100	0	100	2	100	1	100	3	100	2	100	12	100	3	100	7	100	1					100	0
TOTAL VEGETATION COVER	30.39	s=(9.01)		32.78	s=(10.35)	20	1	26	0	21	0	26	2	19	1	34	4	22	2	48	2	22	0	30	2	28	1	43	3	27	2	30	12	31	3	47	7	33	1					40	0
GROUND COVER (Veg+Litter+St.Dead+Rock)	44.28	s=(10.65)		46.67	s=(11.76)	27	1	39	0	45	0	56	2	26	1	40	4	32	2	55	2	28	0	43	2	49	1	52	3	52	2	49	12	39	3	56	7	50	1					59	0
SPECIES DENSITY (# of species/100 sq.m.)	8.11	s=(4.21)				7		17		16		2		5		13		11		7		5		4		12		6		3		6		7		8		8						9	

2017 N-6 Cover Summary and Raw Data

PLANT SPECIES	AVERAGE COVER (%)	FREQUENCY (%)	RELATIVE VEGETATION COVER (%)	AVERAGE COVER-ALL (%)	RELATIVE VEGETATION COVER-ALL (%)	Percent Foliar Cover																																							
						1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16		17		18		19		20	
						1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
NATIVE ANNUAL & BIENNIAL FORBS																																													
Machaeranthera canescens	0.00	5.00	0.00	0.00	0.00													P																											
TOTAL NATIVE ANN. & BIEN. FORBS	0.00	5.00	0.00	0.00	0.00													P																											
INTRODUCED ANNUAL & BIENNIAL FORBS																																													
Kochia scoparia	0.05	5.00	0.17	0.05	0.17															1																									
Melilotus officinalis	0.00	5.00	0.00	0.00	0.00													P																											
Salsola iberica	0.05	10.00	0.17	0.05	0.17															P																						1			
TOTAL INTRO. ANN. & BIEN. FORBS	0.10	15.00	0.35	0.10	0.34													P		1																						1			
INTRODUCED ANNUAL GRASSES																																													
Bromus tectorum	0.30	10.00	1.05	0.40	1.36			1						5	2																														
TOTAL INTRODUCED ANNUAL GRASSES	0.30	10.00	1.05	0.40	1.36			1						5	2																														
NATIVE PERENNIAL FORBS																																													
Penstemon palmeri	0.00	5.00	0.00	0.00	0.00													P																											
Sphaeralcea coccinea	0.00	5.00	0.00	0.00	0.00																													P											
TOTAL NATIVE PERENNIAL FORBS	0.00	10.00	0.00	0.00	0.00													P																P											
INTRODUCED PERENNIAL FORBS																																													
Medicago sativa	0.00	5.00	0.00	0.00	0.00													P																											
TOTAL INTRO. PERENNIAL FORBS	0.00	5.00	0.00	0.00	0.00													P																											
NATIVE PERENNIAL GRASSES (cool)																																													
Agropyron smithii	1.45	60.00	5.05	1.45	4.93	1		1						8				2		1		1						P						5		1		5		2		2			
Agropyron spicatum	0.70	15.00	2.44	0.70	2.38									2				9																								3			
Hilaria jamesii	2.65	60.00	9.23	2.75	9.35			16	2	2		3		P						5		2		4				3		6						8		1				3			
Oryzopsis hymenoides	0.80	50.00	2.79	0.80	2.72	P		P				1		10				P		P		4						1						P		P									
Sitanion hystrix	0.15	20.00	0.52	0.20	0.68			P						P						3	1							P																	
Stipa comata	0.00	5.00	0.00	0.00	0.00															P																									
TOTAL NATIVE PERENNIAL GRASSES (c)	5.75	80.00	20.03	5.90	20.07	1		17	2	2		4		20				11		9	1	7		4				4		6				5		9		6		2		8			
NATIVE PERENNIAL GRASSES (warm)																																													
Aristida purpurea	0.15	10.00	0.52	0.15	0.51													P																								3			
Bouteloua curtipendula	0.00	5.00	0.00	0.00	0.00																																					P			
Bouteloua gracilis	1.40	55.00	4.88	1.45	4.93	P		1										1		6		3		P				11	1	3						P		3				P			
Buchloe dactyloides	0.10	15.00	0.35	0.10	0.34																	2						P										P							
Sporobolus airoides	0.30	10.00	1.05	0.30	1.02																									1								5							
Sporobolus cryptandrus	0.20	25.00	0.70	0.20	0.68			2														1														P		P				1			
TOTAL NATIVE PERENNIAL GRASSES (w)	2.15	55.00	7.49	2.20	7.48	P		3										1		6		6		P				11	1	4						P		8				4			
INTRODUCED PERENNIAL GRASSES (cool)																																													
Agropyron desertorum	0.20	15.00	0.70	0.20	0.68	3		1																																P					
Elymus junceus	13.40	95.00	46.69	13.70	46.60	7				25		P		2		23		2		9		10		24		26	1	3		18	1	24	1	13		11		9	2	16		19		27	1
TOTAL INTRO. PERENNIAL GRASSES (c)	13.60	100.00	47.39	13.90	47.28	10		1		25		P		2		23		2		9		10		24		26	1	3		18	1	24	1	13		11		9	2	16		19		27	1
NATIVE SUBSHRUBS																																													
Ceratoides lanata	0.00	20.00	0.00	0.00	0.00							P										P												P						P					
Gutierrezia sarothrae	0.15	45.00	0.52	0.15	0.51	1				P				1				P				P						P						1		P				P					
Senecio douglasii var. longilobus	0.00	10.00	0.00	0.00	0.00	P								P																															
TOTAL NATIVE SUBSHRUBS	0.15	50.00	0.52	0.15	0.51	1				P		P		1				P				P						P						1		P				P					
INTRODUCED SUBSHRUBS																																													
Kochia prostrata	2.20	30.00	7.67	2.20	7.48							39						1		P		1																		P				3	
TOTAL INTRO. SUBSHRUBS FORBS	2.20	30.00	7.67	2.20	7.48							39						1		P		1																		P				3	
NATIVE SHRUBS																																													
Artemisia tridentata	0.25	10.00	0.87	0.25	0.85			5						P																															
Atriplex canescens	3.90	95.00	13.59	3.95	13.44	3		12		1				10		2		2		11		P		1		12	1	P		8		1		1		1		4		1		2		6	
Atriplex confertifolia	0.00	10.00	0.00	0.00	0.00																													P						P					
Chrysothamnus nauseosus	0.30	20.00	1.05	0.30	1.02	P												5				1						P																	
Purshia tridentata	0.00	5.00	0.00	0.00	0.00													P																											
TOTAL NATIVE SHRUBS	4.45	95.00	15.51	4.50	15.31	3		17		1				10		2		7		11		1		1		12	1	P		8		1		1		1		4		1		2		6	
SUCCULENTS																																													
Opuntia phaeacantha	0.00	10.00	0.00	0.05	0.17									P																P	1														
TOTAL SUCCULENTS	0.00	10.00	0.00	0.05	0.17									P																P	1														
Standing dead	1.00	40.00		1.00				3						2		3		7				1						2		1												1			
Litter	15.80	100.00		15.80		14		22		6		17		15		13		18		30		18		13		11		18		9		11		23		10		18		17		21		12	
Bare ground	51.60	100.00		51.60		63		36		62		39		45		57		53		32		46		56		50		60		53		63		54		69		53		59		31		51	
Rock	2.90	80.00		2.90		8				4		1				2				2		10		2		1		2		1		1		3				2		5		13		1	
TOTALS	100.00		100.00	100.70	100.00	100	0	100	2	100	0	100	0	100	2	100	0	100	0	100	1	100	0	100	0	100	2	100	1	100	2	100	1	100	0	100	0	100	2	100	0	100	0	100	1
TOTAL VEGETATION COVER	28.70	s=(8.25)		29.40	s=(8.72)	15	0	39	2	28	0	43	0	38	2	25	0	22	0	36	1	25	0	29	0	38	2	18	1	36	2	25	1	20	0	21	0	27	2	19	0	34	0	36	1
GROUND COVER (Veg+Litter+St.Dead+Rock)	48.40	s=(10.62)		49.10	s=(10.87)	37	0	64	2	38	0	61	0	55	2	43	0	47	0	68	1	54	0	44	0	50	2	40	1	47	2	37	1	46	0	31	0	47	2	41	0	69	0	49	1
SPECIES DENSITY (# of species/100 sq.m.)	7.45	s=(3.8)				9		10		4		5		12		2		15		11		12		4		2		10		6		2		8		8		8		8		10		3	

TAB 6

FACILITIES

N-6, J-1, J-16, and N-14

Reclamation Liability Release Application (RLRA)

TAB 6

TABLE OF CONTENTS

MAPS

TAB 6

FACILITIES

Introduction

The only permanent facilities located in the N-6, J-1, J-16, and N-14 Reclamation Liability Release Areas (RLRA) include an ancillary road in the northwest portion of N-6 and one permanent impoundment as shown on Map 1.1.A and Map 1.1.B. Ancillary roads adjacent to the RLRA areas are not included in this application. The boundaries of the RLRA areas are for the most part existing fence line locations or limits of Pre-Law and Permanent Program disturbance.

N-6, J-1, J-16, and N-14 RLRA Facilities

The unpaved road located on the northwestern side of the N-6 RLRA is used by PWCC when monitoring the N5-A and N5-G ponds located outside of the RLRA and by local residents to access their grazing areas.

The facilities also consist of one permanent impoundment designated as N14-F. Water quality data collected from the N14-F pond is presented and discussed in Tab 3 of this application. Permanent impoundments are discussed in the AZ-0001 permit in Volume 1, Chapter 3, Pages 76 to 78; in Volume 27, Parts 1 and 2; in Volume 38, Part 1; and in the AZ-0001F Permit in Volume 1, Chapter 6, Pages 73 to 86 and in Volume 11, Chapter 23, Pages 42 to 44. The N14-F pond has an approximate drainage area of 376 acres (see Drawing 85406, Sheet 1 of 2 in Volume 22 of Permit AZ-0001F). The “As-built” report for Pond N14-F is included as Drawing 85424 in Volume 22 of Permit AZ-0001F.

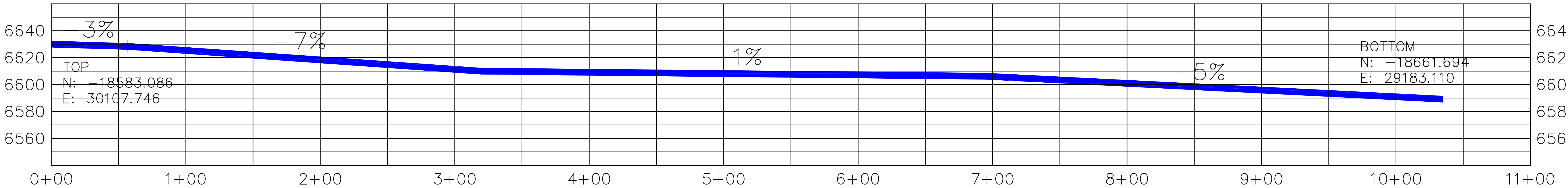
The overall Kayenta Complex livestock and wildlife watering facilities discussion can be found in the AZ-0001F permit, Volume 11, Chapter 23, Livestock and Wildlife Watering Facilities section; Volume 1, Chapter 6, Permanent Impoundments section; on Drawing No. 85324 in Volume 20; and in the AZ-0001 Permit, Volume 27, Part 2, Appendix E. Due to the extensive nature of these reports, this material is not duplicated in this application. Permanent impoundment N14-F was constructed in accordance with 30 CFR 816.49(b) and will be released to the Navajo Tribe and local residents as part of the postmining topography.

Information addressing the six criteria for permanent impoundments in 30 CFR 816.49(b) pertinent to the on permanent impoundment in the N-14 RLRA can be found in Tab 3 of this RLRA application, in Permit AZ-0001, Volume 27, Part 2, Appendix E; I the AZ-0001F Permit, Volume 11, Chapter 18, the 1/17/94 letter and appendices to Rick Williamson responding to concerns and technical deficiencies to Chapter 16 of Permit AZ-0001D; and all AHR’s since 1982.

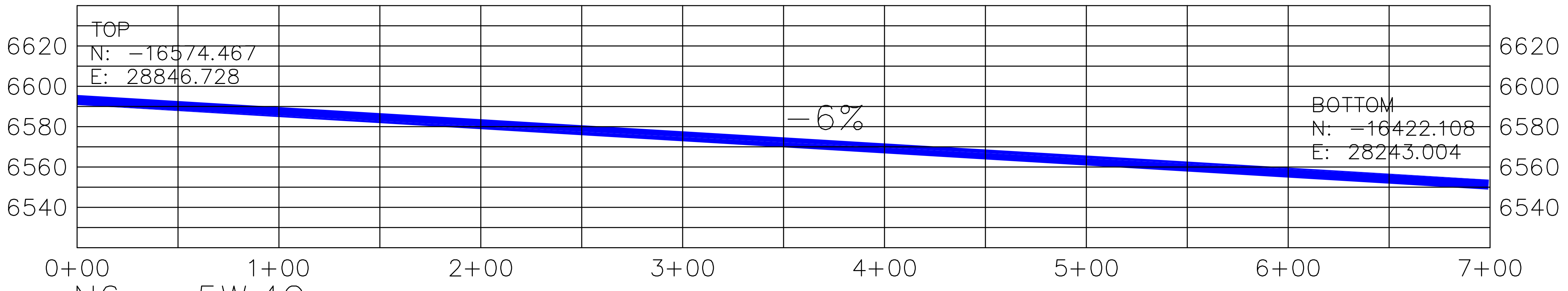
Engineering design and location information for the terraces, downdrains, and reclaimed channels in the J-1/N-6, N-14, and J-16 RLRA areas are presented on Maps 6.1.A, 6.1.B, and 6.1.C. SedCad design hard copy reports for these structures are available in PWCC's engineering reclamation files at the N-8 Operations office of the Kayenta Complex. Electronic SedCad model files are included with this RLRA.

Conclusion

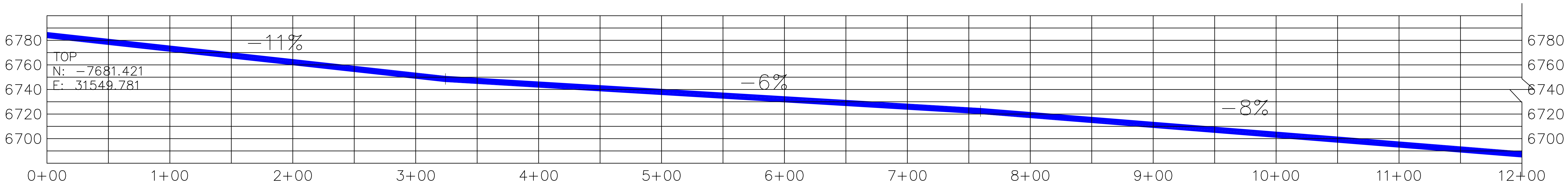
The permanent facilities will remain and will enhance and compliment the postmining land use. PWCC requests approval from OSMRE, Tribal agencies, and the local transportation committee, if applicable to leave the ancillary road discussed above. This road will be maintained in a manner that other similar residential and range access roads have been traditionally maintained prior to any mining disturbance.



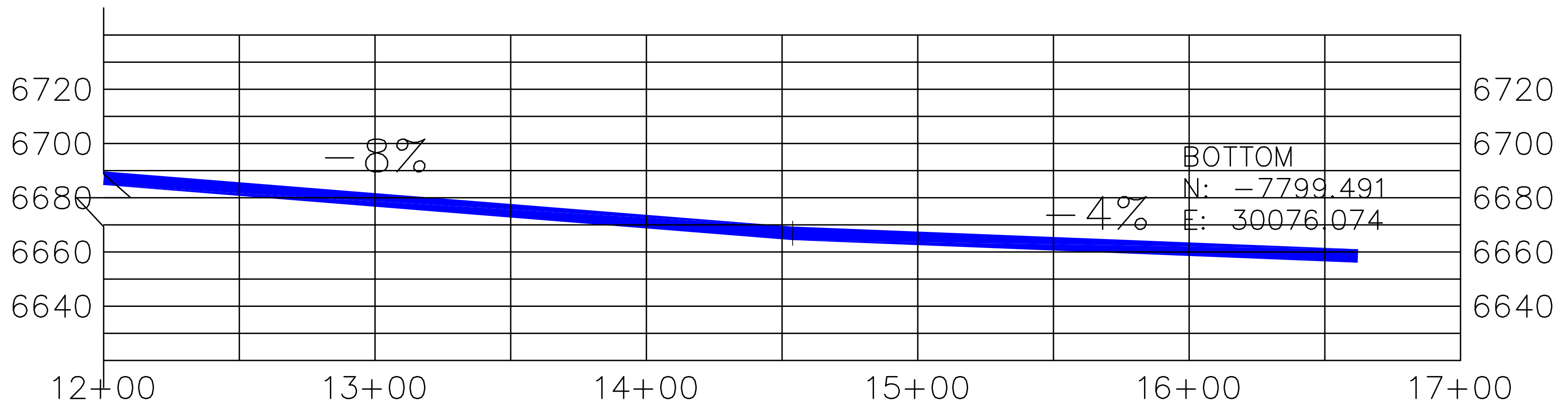
J1 — 1W.1C



N6 — 5W.4C



N6 — 10W.1C



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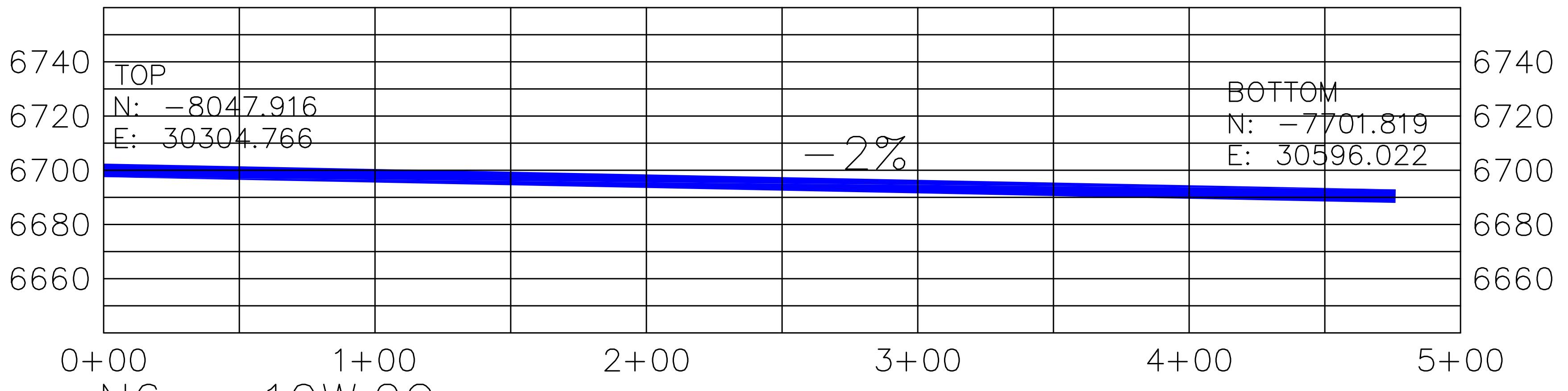
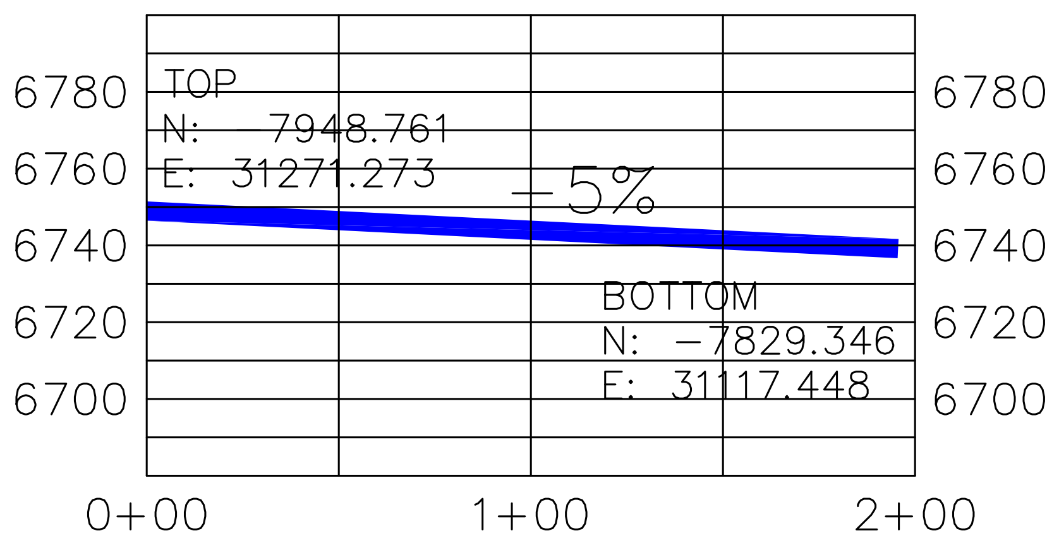
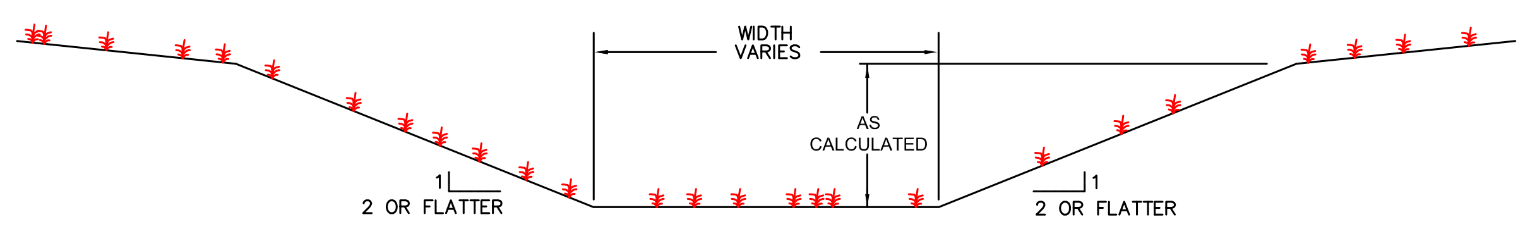


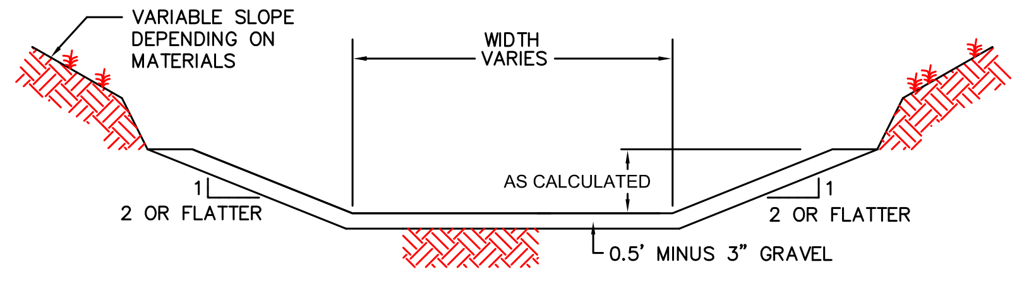
N6 — 10W.2C



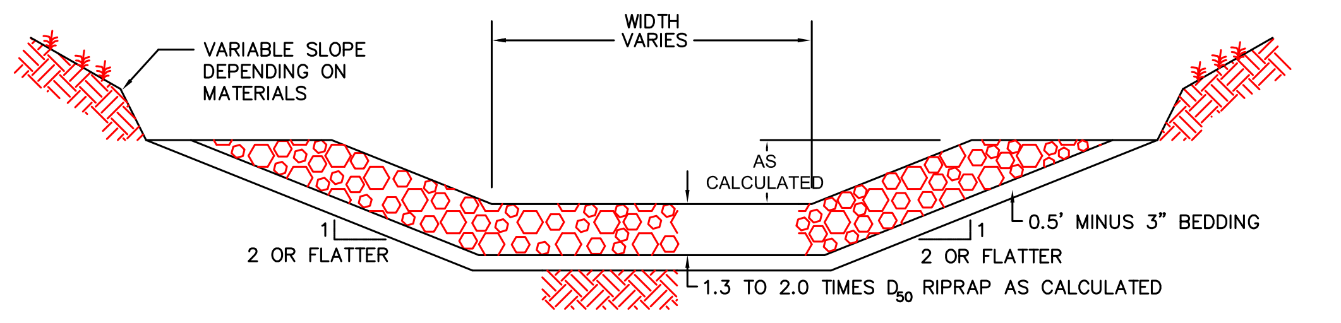
N6 — 10W.3C



TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN A
SPOIL/SOIL MIXED WITH VEGETATION
(NOT DRAWN TO SCALE)



TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN B
GRAVEL MIXED WITH VEGETATION
(NOT DRAWN TO SCALE)



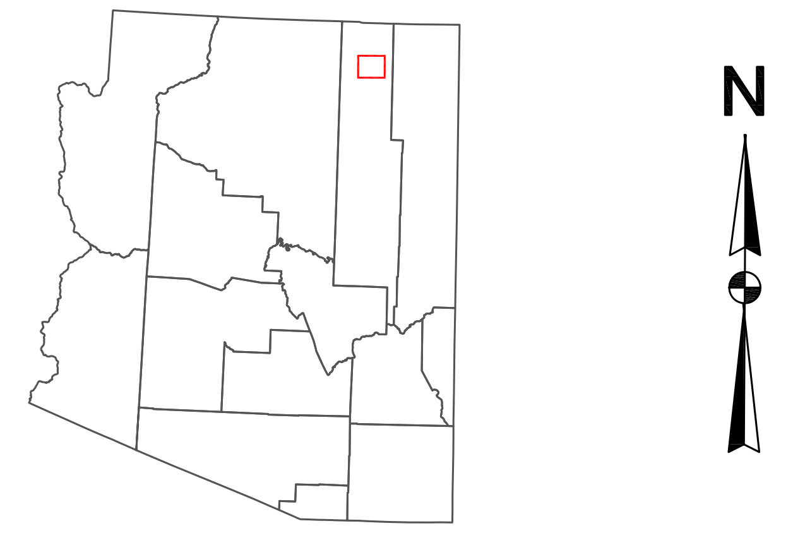
TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN C
(NOT DRAWN TO SCALE)

NOTES:
1) For channel locations, see Map 6.1.A, (Sheet 1 of 4).
2) Channel profiles shown are for released areas only.

ENGINEER'S CERTIFICATION

37842
GARY ALTSISI
EXPIRES: 09/30/2020

Gary Altsisi
ARIZONA P.E. 37842



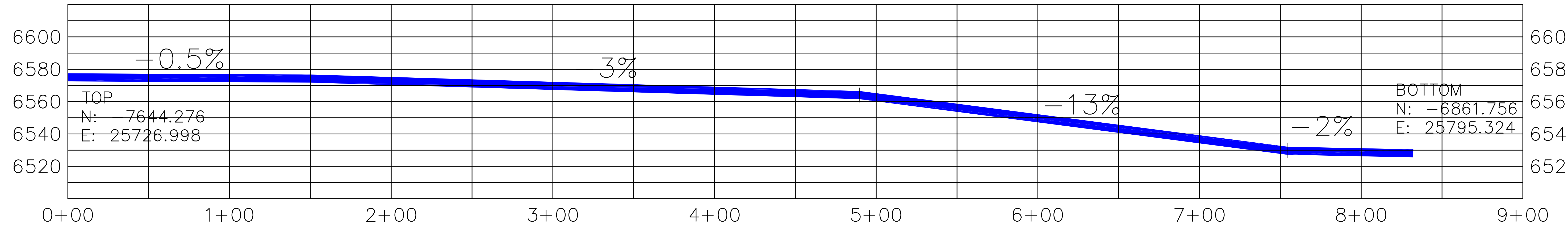
REVISION	REV'D BY	DATE

KAYENTA MINE
Peabody
P.O. BOX 650
KAYENTA, ARIZONA 86033

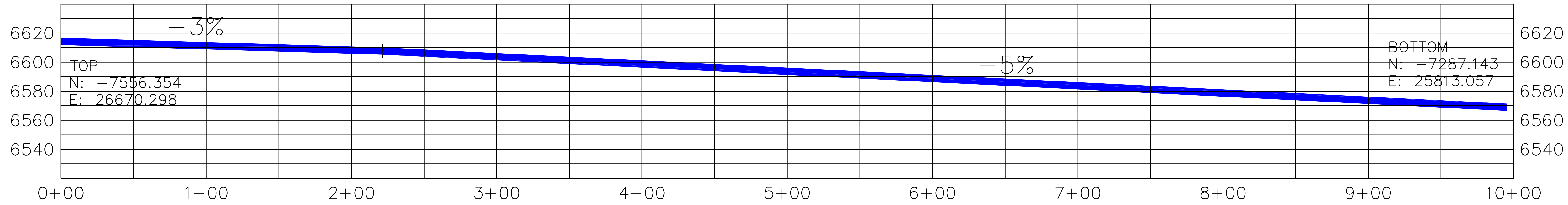
MAP 6.1.A (SHEET 2 OF 4)
J-1/N-6 CHANNEL PROFILES

DESIGNED BY:	G.A	**COUNTRY:**	USA
DRAWN BY:	G.E	**STATE/PROVINCE:**	ARIZONA
APPROVED BY:	G.A.	**GCS:**	DATUM/Projection
DATE:	2019-06-18	**DRAWING/SHEET:**	2 of 4
SCALE:	1" = 50'	**C.I.:**	

0 50 100 150
FEET



N6 – 11W.1C



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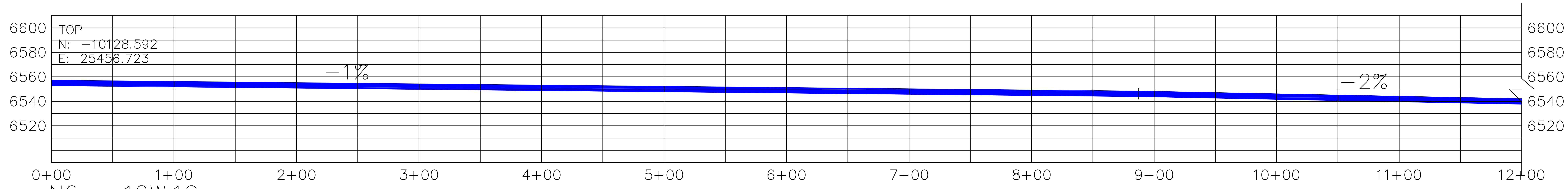
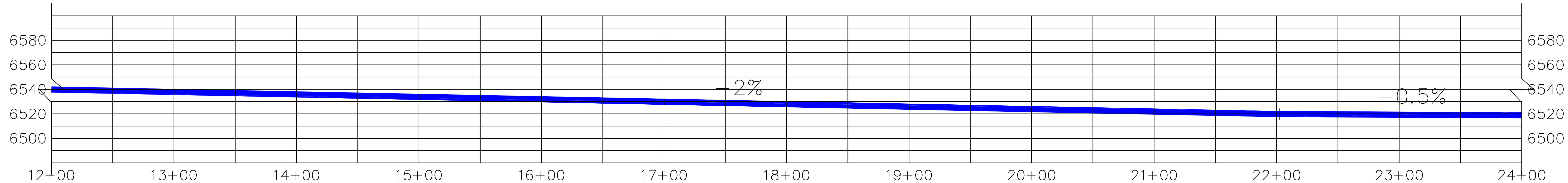


N6 – 12W.1C



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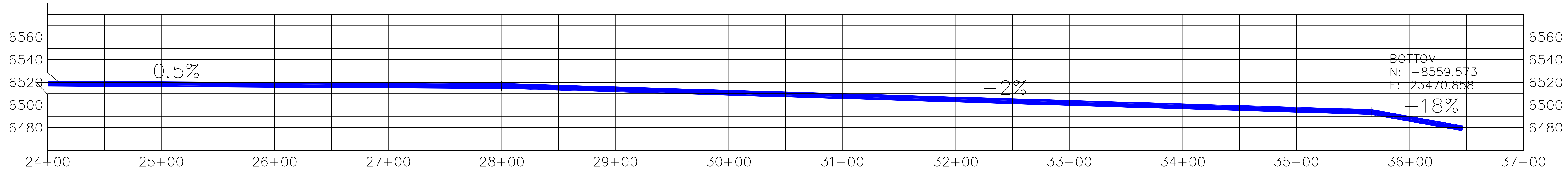

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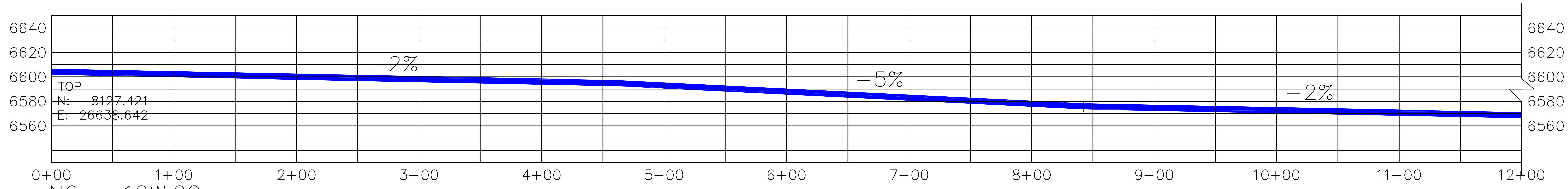
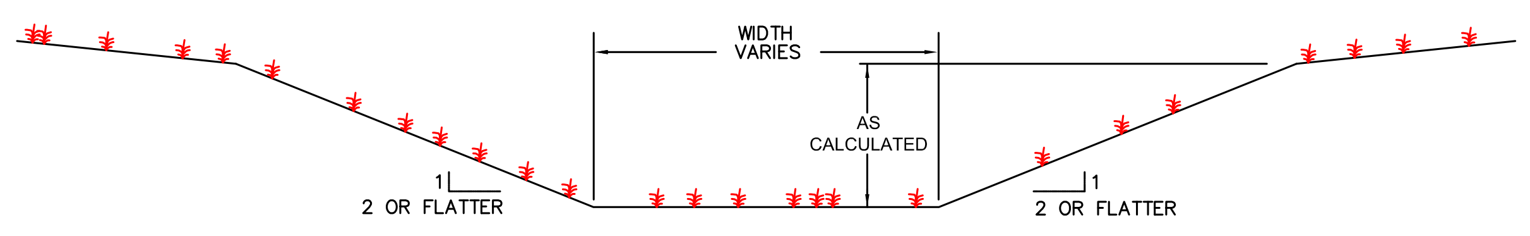
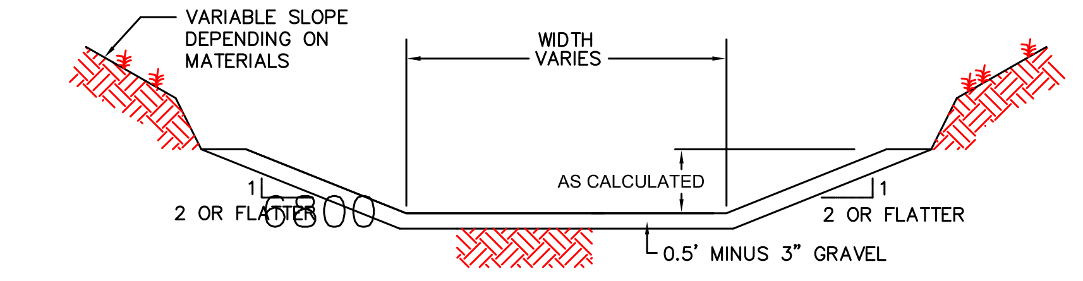


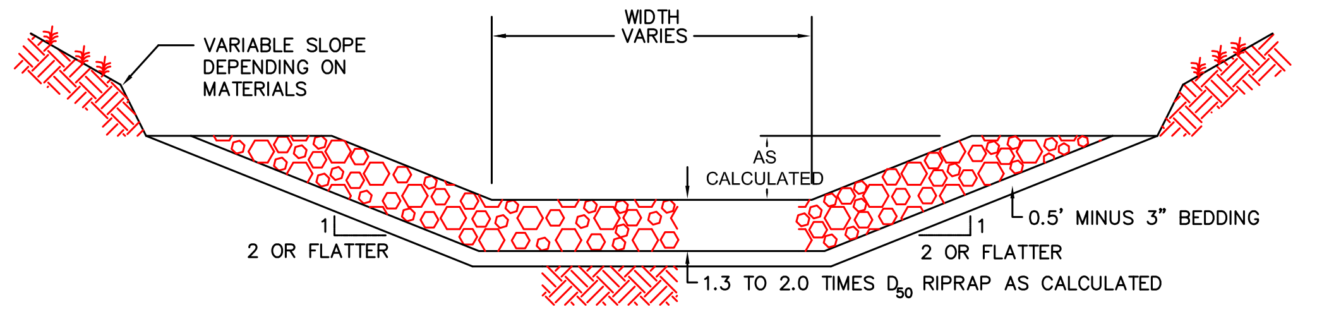
N6 – 12W.2C



TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN A
SPOIL/SOIL MIXED WITH VEGETATION
(NOT DRAWN TO SCALE)



TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN B
GRAVEL MIXED WITH VEGETATION
(NOT DRAWN TO SCALE)



TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN C
(NOT DRAWN TO SCALE)

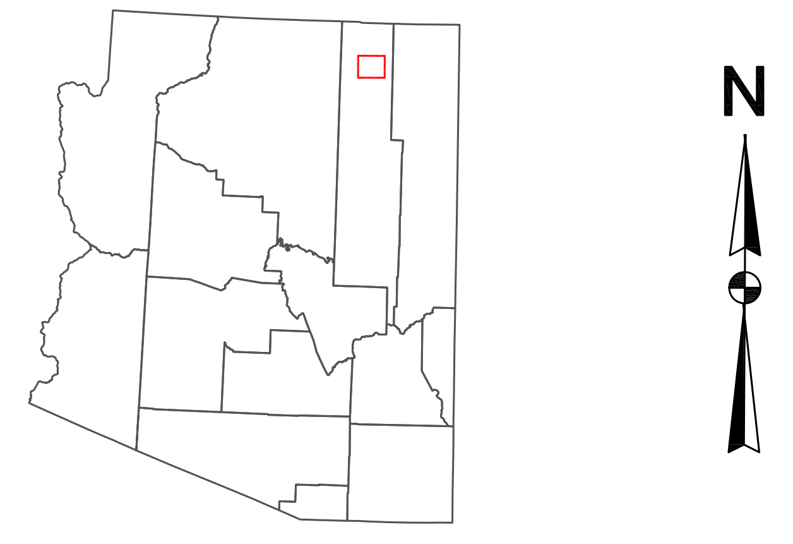
NOTES:
1) For channel locations, see Map 6.1.A, (Sheet 1 of 4).
2) Channel profiles shown are for released areas only.

ENGINEER'S CERTIFICATION

Registered Professional Engineer (Civil)
CERTIFICATE NO. 37842
GARY ALTSISI
Date signed: 06/18/19
ARIZONA, USA

EXPIRES: 09/30/2020

Gary Altsisi
ARIZONA P.E. 37842



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KAYENTA MINE
Peabody
P.O. BOX 650
KAYENTA, ARIZONA 86033

MAP 6.1.A (SHEET 3 OF 4)
J-1/N-6 CHANNEL PROFILES

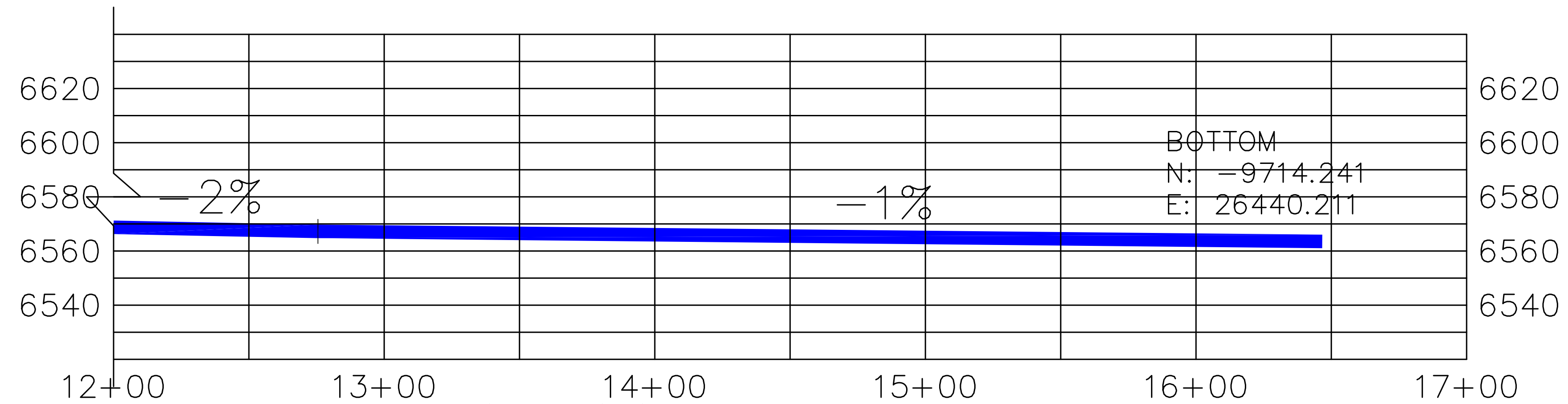
DESIGNED BY: G.A
DRAWN BY: G.E
APPROVED BY: G.A.

COUNTRY: USA
STATE/PROVINCE: ARIZONA
GCS: DATUM/Projection

DATE: 2019-06-18
SCALE: 1" = 50'

DRAWING/SHEET: 3 of 4
C.I.:

0 50 100 150 FEET



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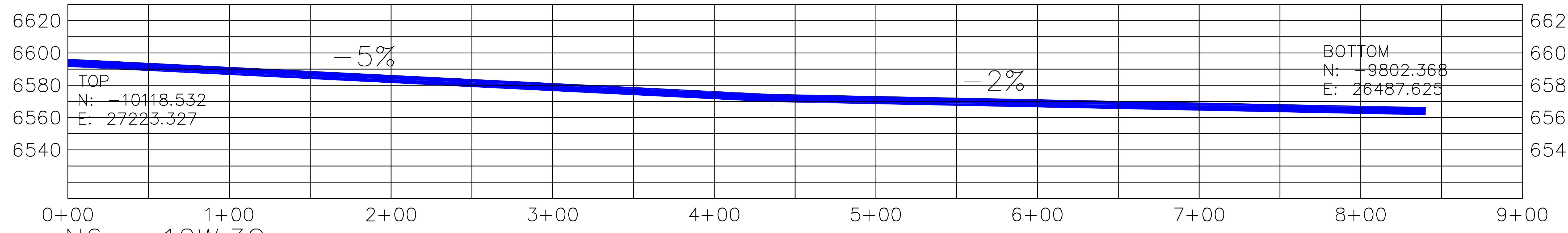
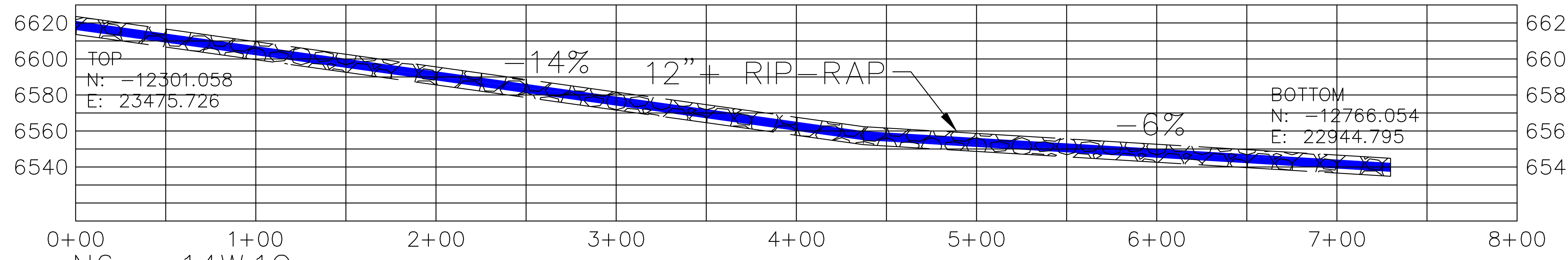


N6 – 12W.3C



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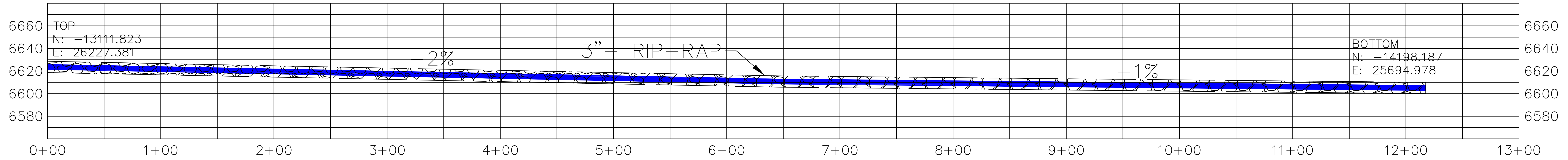

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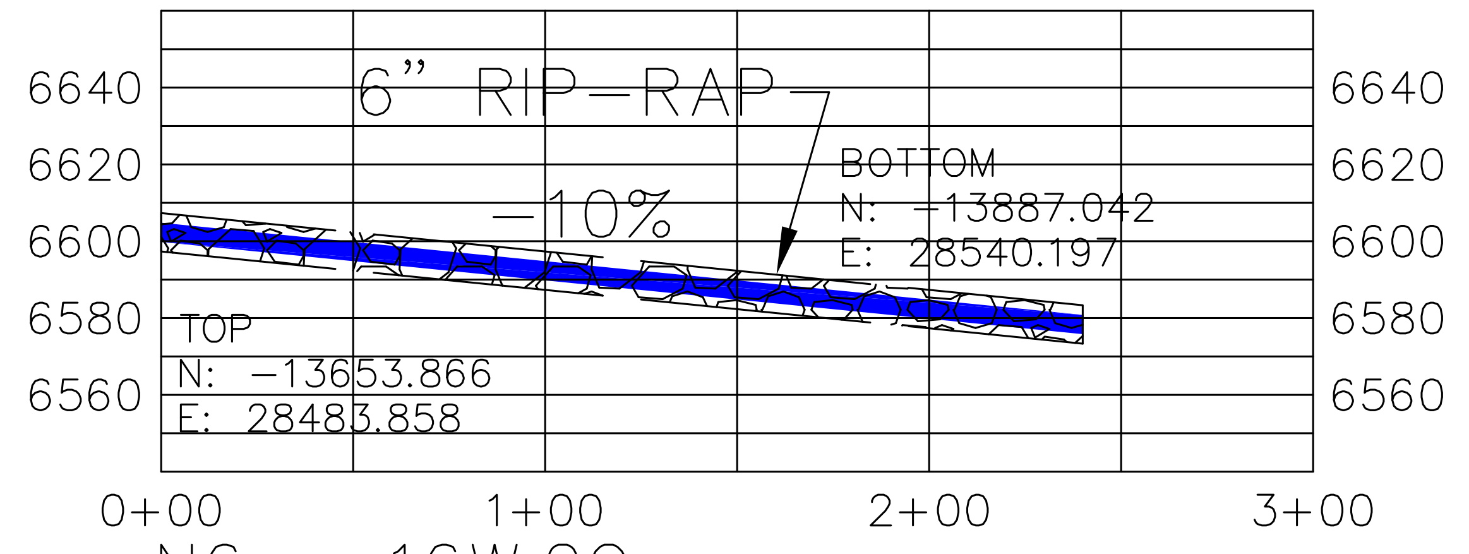

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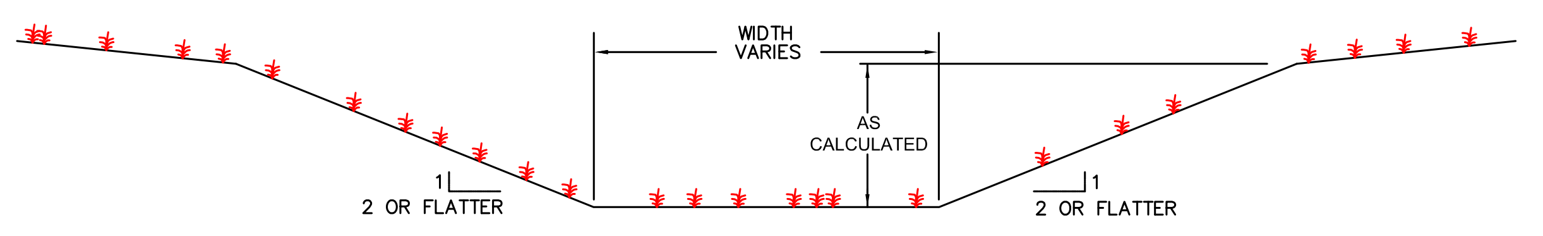
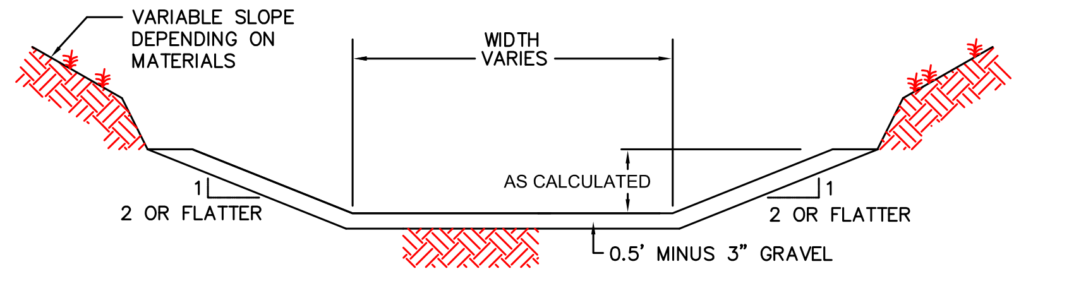
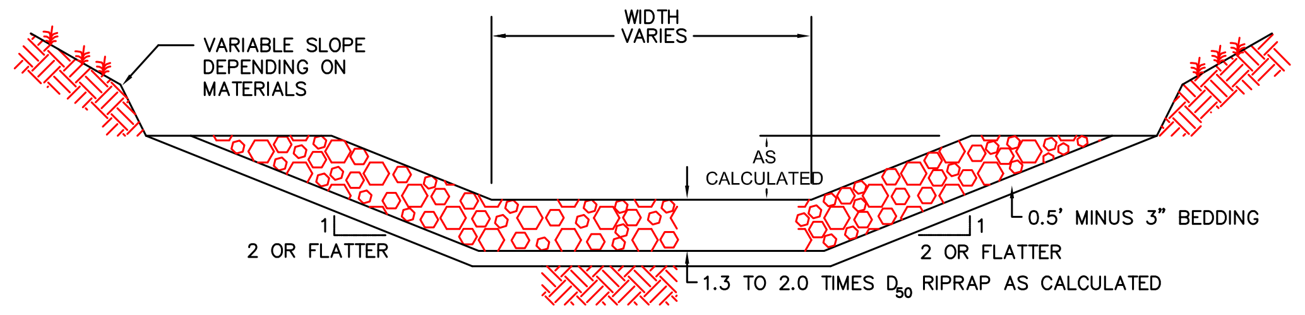


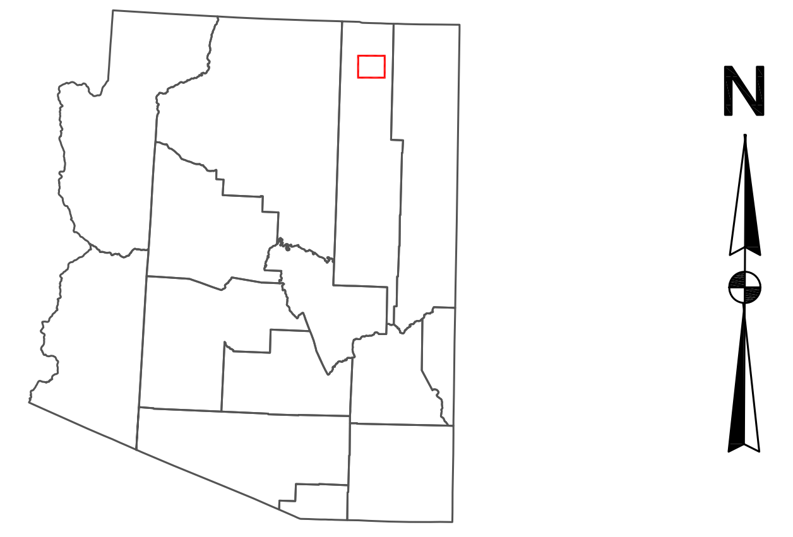
TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN A
SPOIL/SOIL MIXED WITH VEGETATION
(NOT DRAWN TO SCALE)



TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN B
GRAVEL MIXED WITH VEGETATION
(NOT DRAWN TO SCALE)



TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN C
(NOT DRAWN TO SCALE)



REVISION	REV'D BY	DATE

NOTES:
1) For channel locations, see Map 6.1.A, (Sheet 1 of 4).
2) Channel profiles shown are for released areas only.

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EXPIRES: 09/30/2020

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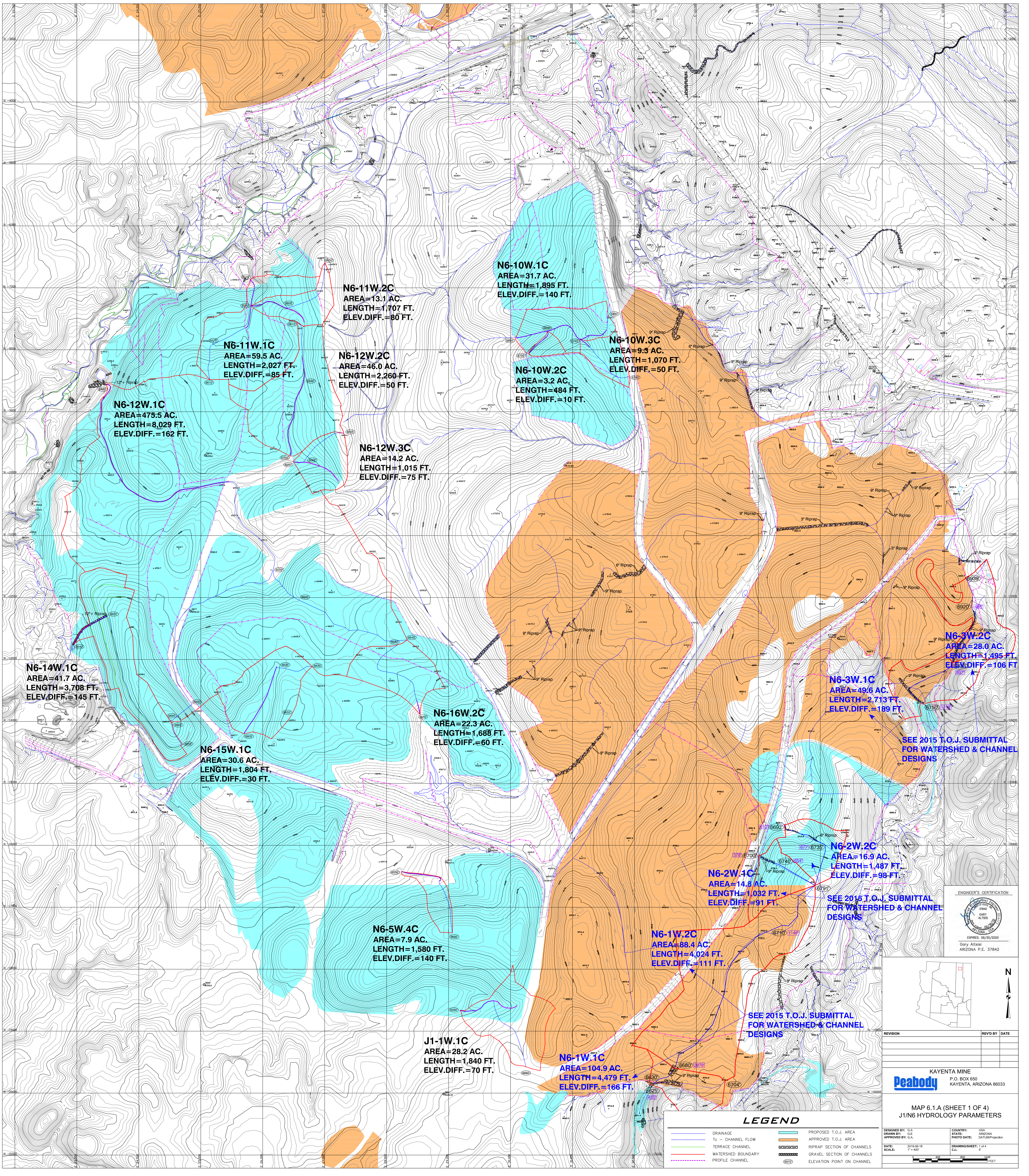
ARIZONA P.E. 37842

KAYENTA MINE
Peabody
P.O. BOX 650
KAYENTA, ARIZONA 86033

MAP 6.1.A (SHEET 4 OF 4)
J-1/N-6 CHANNEL PROFILES

DESIGNED BY:	G.A	**COUNTRY:**	USA
DRAWN BY:	G.E	**STATE/PROVINCE:**	ARIZONA
APPROVED BY:	G.A.	**GCS:**	DATUM/Projection
DATE:	2019-06-18	**DRAWING/SHEET:**	4 of 4
SCALE:	1" = 50'	**C.I.:**	

0 50 100 150 FEET



LEGEND

─	DRAINAGE	🟦	PROPOSED T.O.J. AREA
─	Tc – CHANNEL FLOW	🟧	APPROVED T.O.J. AREA
─	TERRACE CHANNEL	▨	RIPRAP SECTION OF CHANNELS
─	WATERSHED BOUNDARY	▩	GRAVEL SECTION OF CHANNELS
┅	PROFILE CHANNEL	6975'	ELEVATION POINT ON CHANNEL

ENGINEER'S CERTIFICATION

Registered Professional Engineer (Civil)
CERTIFICATE NO. 37842
GARY ALTSISI
Date signed: 06/18/19
ARIZONA, USA

EXPIRES: 09/30/2020

Gary Altsisi
ARIZONA P.E. 37842

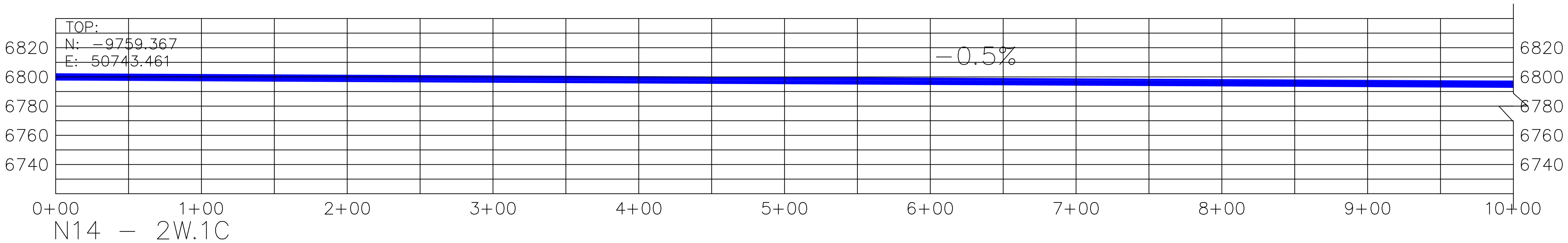
REVISION	REV'D BY	DATE

KAYENTA MINE
Peabody
P.O. BOX 650
KAYENTA, ARIZONA 86033

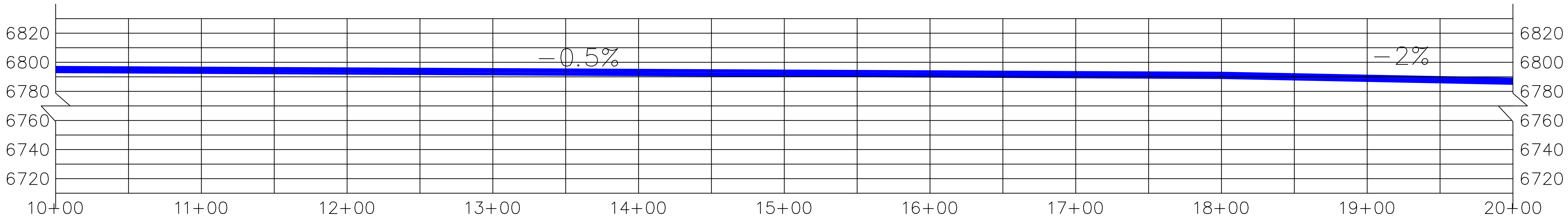
MAP 6.1.A (SHEET 1 OF 4)
J1/N6 HYDROLOGY PARAMETERS

DESIGNED BY: G.A
DRAWN BY: G.E
APPROVED BY: G.A.
COUNTRY: USA
STATE: ARIZONA
PHOTO DATE: DATUM/Projection
DATE: 2019-06-18
SCALE: 1" = 400'
DRAWING/SHEET: 1 of 4
C.I.: 5'

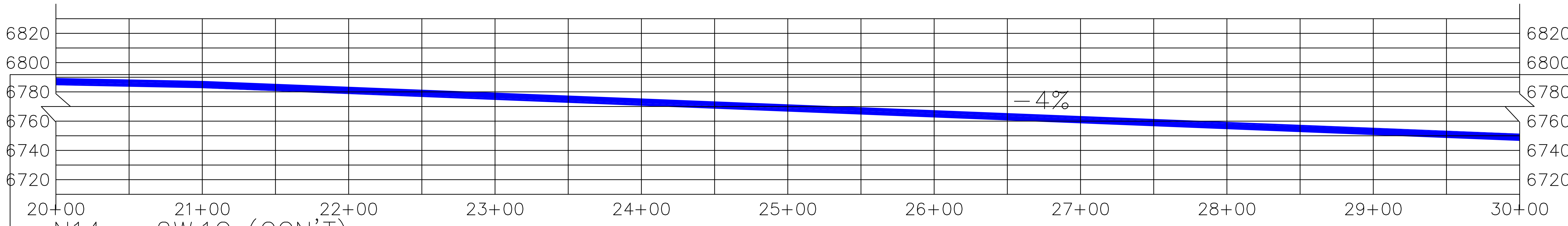
0 400 800 1600 FEET



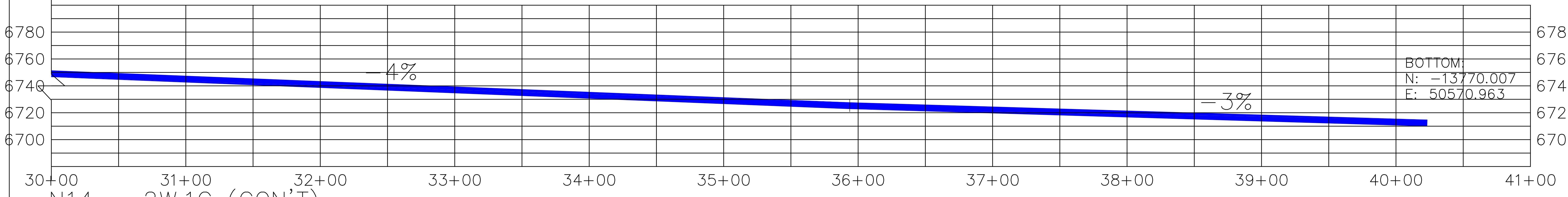
N14 – 2W.1C



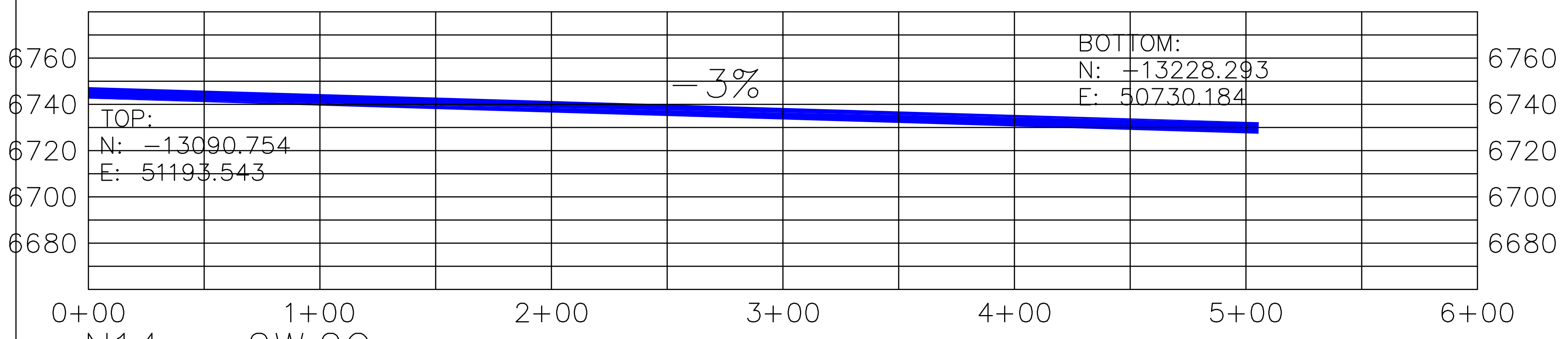
N14 – 2W.1C (CON'T)



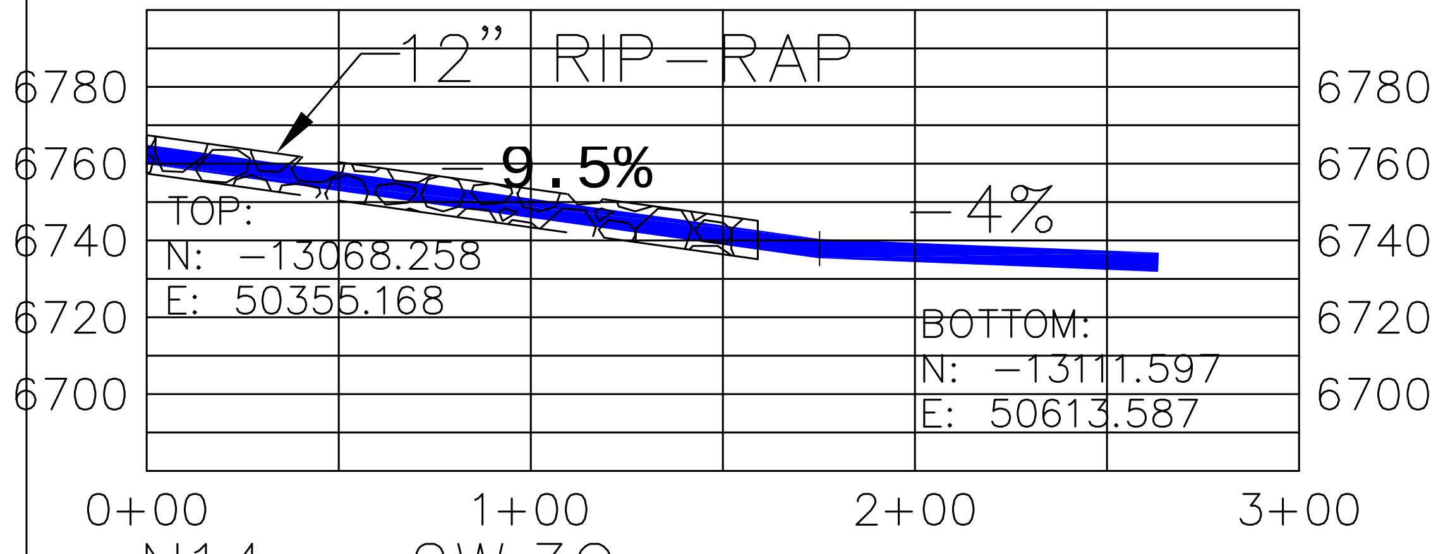
N14 – 2W.1C (CON'T)



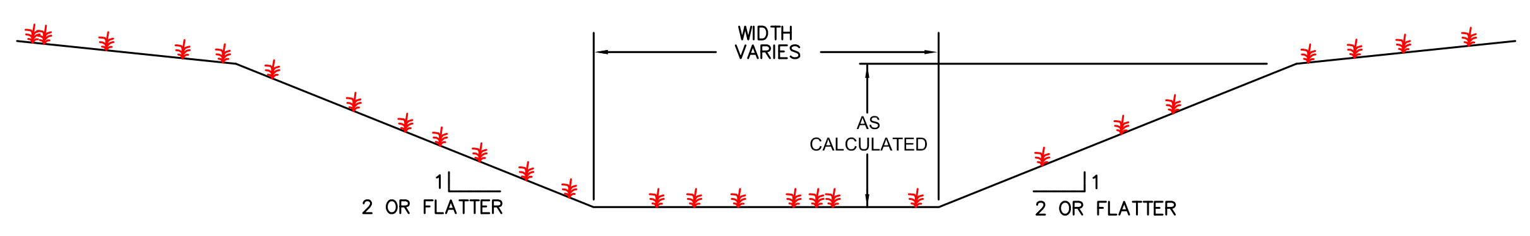
N14 – 2W.1C (CON'T)



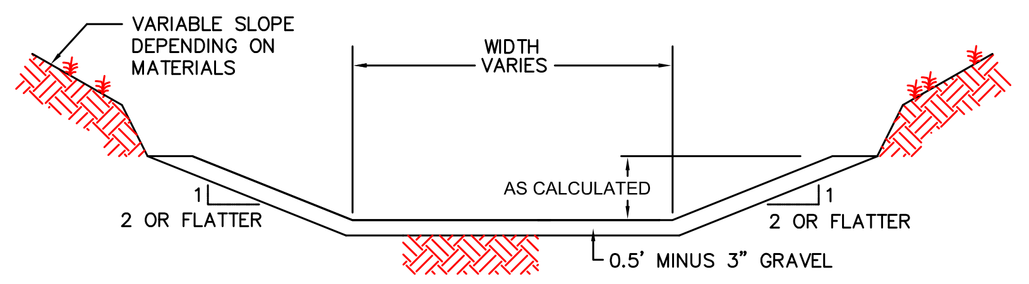
N14 – 2W.2C



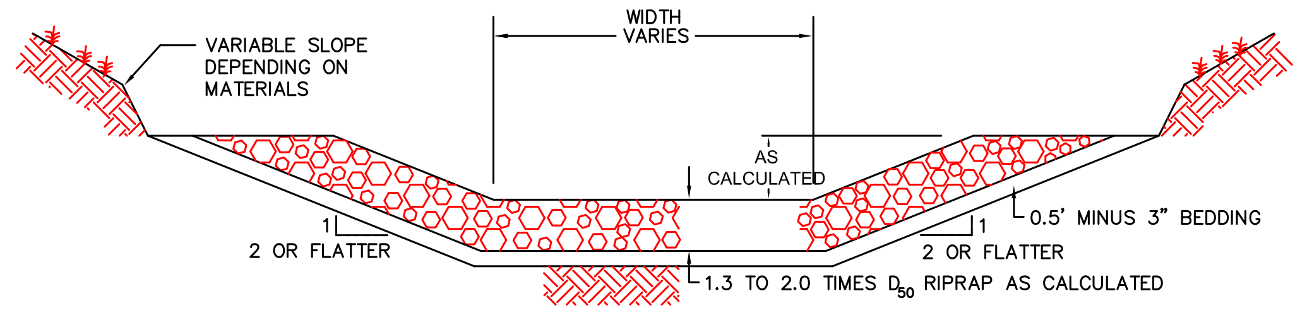
N14 – 2W.3C



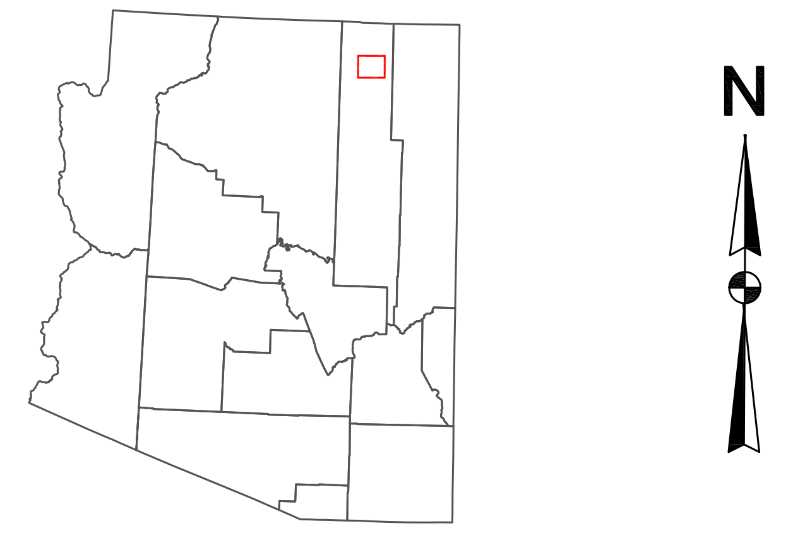
TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN A
SPOIL/SOIL MIXED WITH VEGETATION
(NOT DRAWN TO SCALE)



TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN B
GRAVEL MIXED WITH VEGETATION
(NOT DRAWN TO SCALE)



TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN C
(NOT DRAWN TO SCALE)



REVISION	REV'D BY	DATE

NOTES:
1) For channel locations, see Map 6.1.B, (Sheet 1 of 3).
2) Channel profiles shown are for released areas only.

ENGINEER'S CERTIFICATION

Registered Professional Engineer (Civil)
Certificate No. 37842
GARY ALTSISI
Date signed: 06/18/19
ARIZONA, USA

EXPIRES: 09/30/2020

Gary Altsisi
ARIZONA P.E. 37842

KAYENTA MINE
Peabody
P.O. BOX 650
KAYENTA, ARIZONA 86033

MAP 6.1.B (SHEET 2 OF 3)
N-14 CHANNEL PROFILES

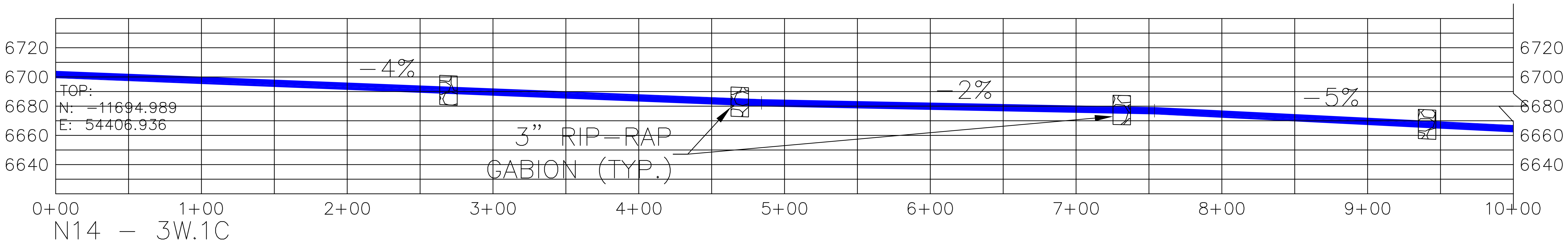
DESIGNED BY: G.A
DRAWN BY: G.E
APPROVED BY: G.A.

COUNTRY: USA
STATE/PROVINCE: ARIZONA
GCS: DATUM/Projection

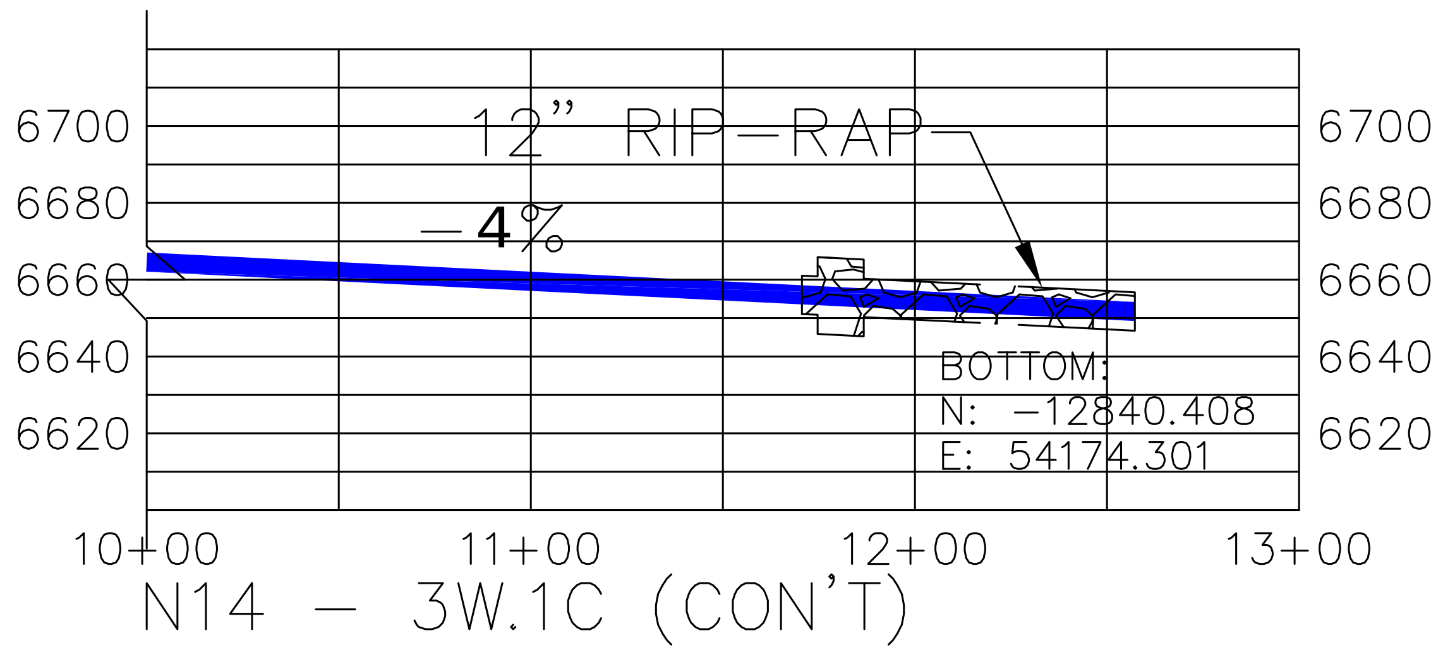
DATE: 2019-06-18
SCALE: 1" = 50'

DRAWING/SHEET: 2 of 3
C.I.:

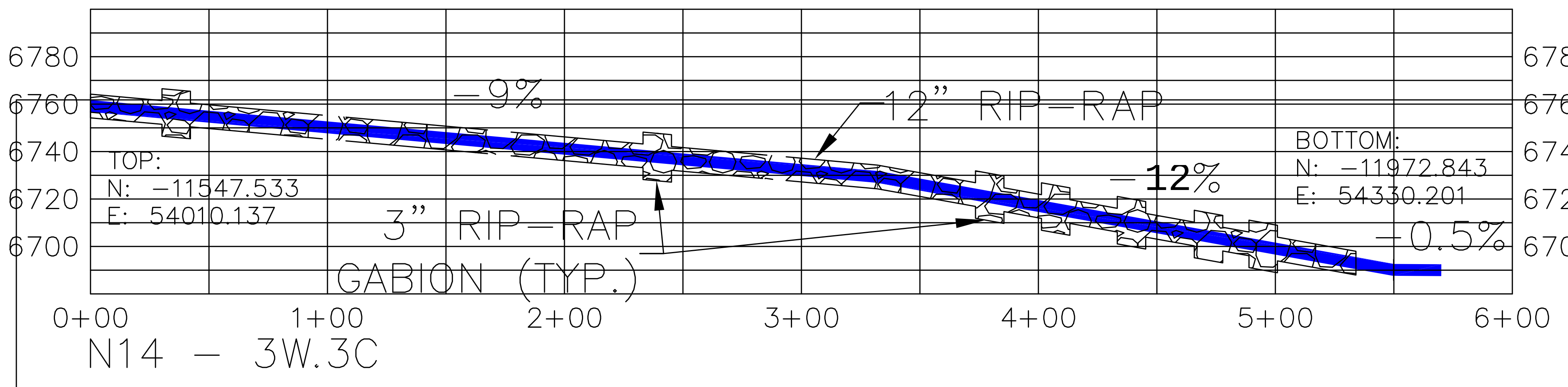
0 50 100 150 FEET



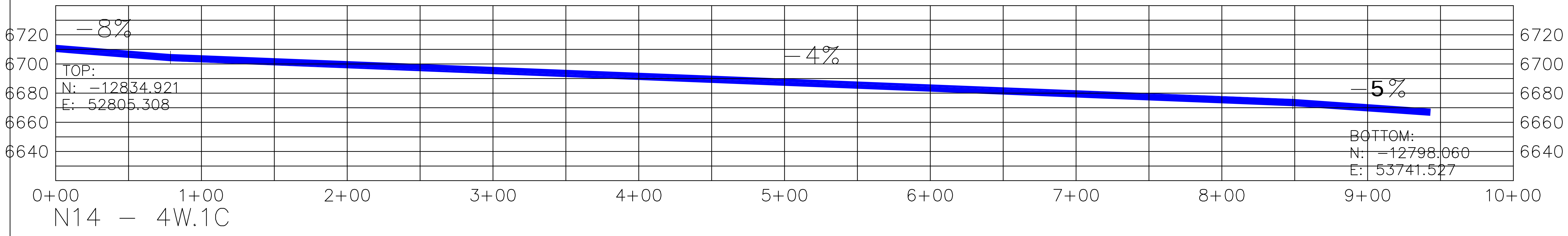
N14 – 3W.1C



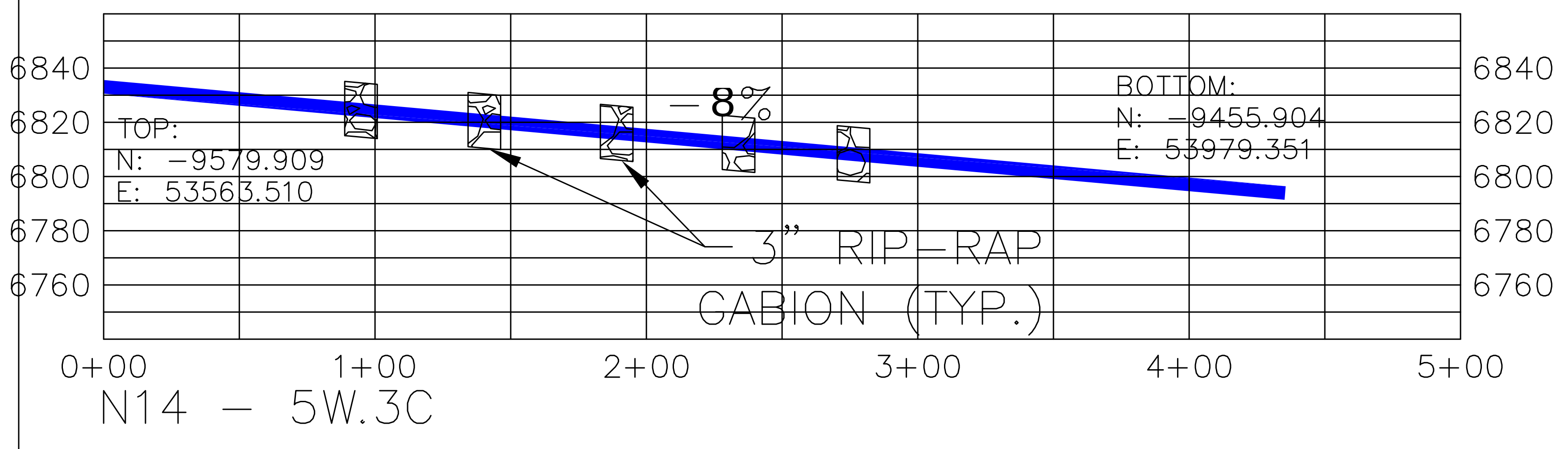
N14 – 3W.1C (CON'T)



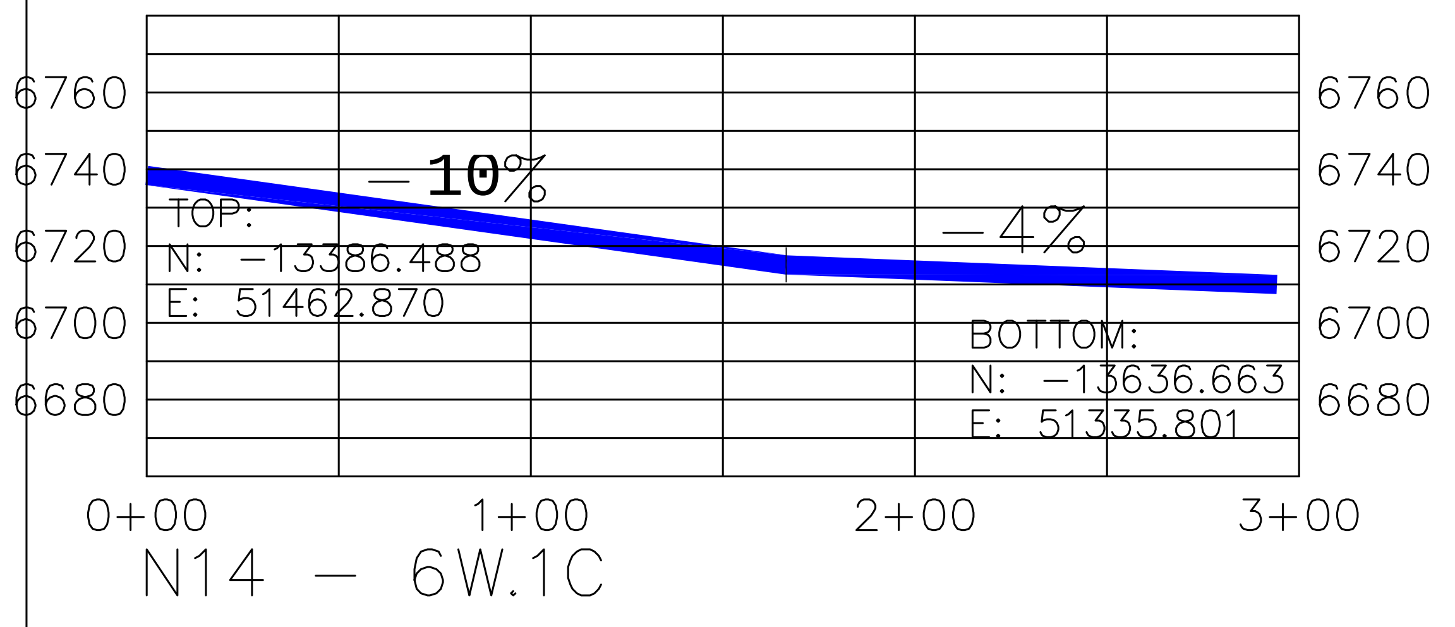
N14 – 3W.3C



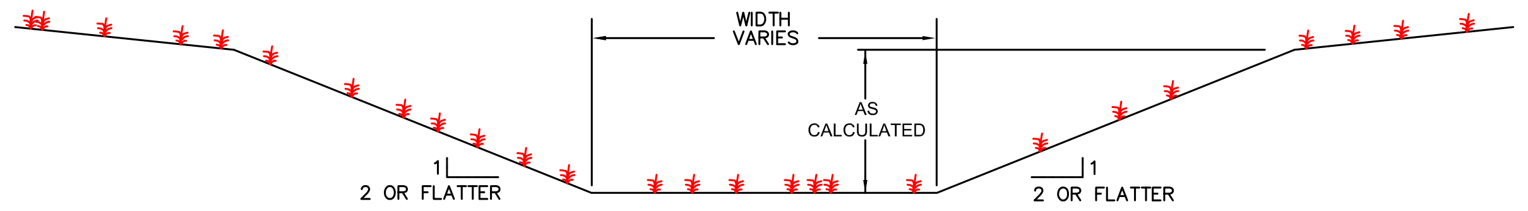
N14 – 4W.1C



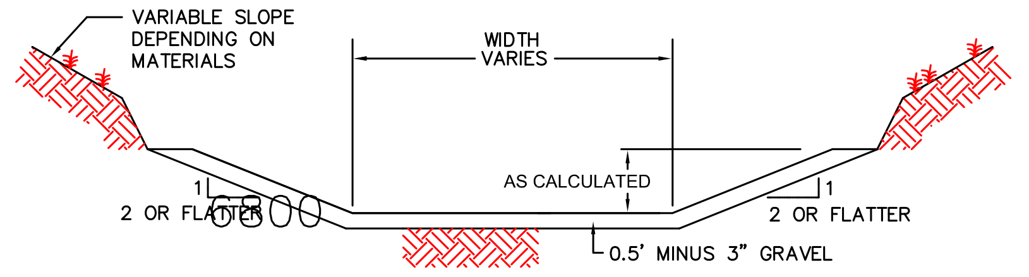
N14 – 5W.3C



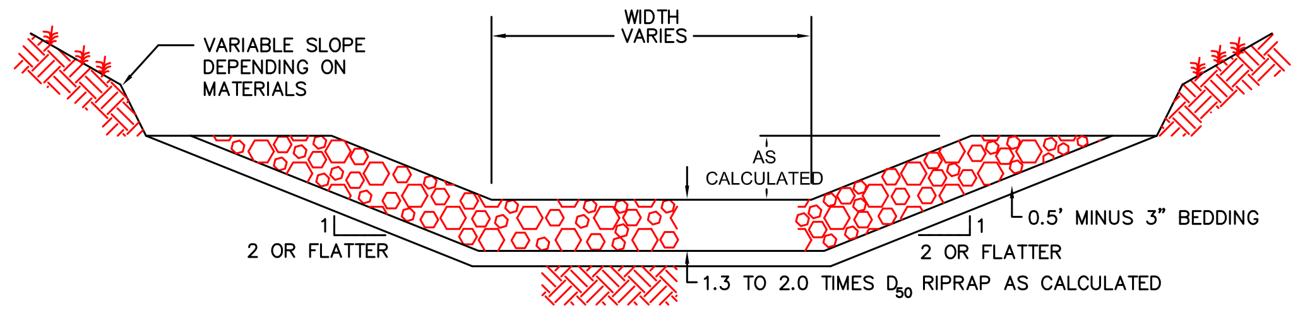
N14 – 6W.1C



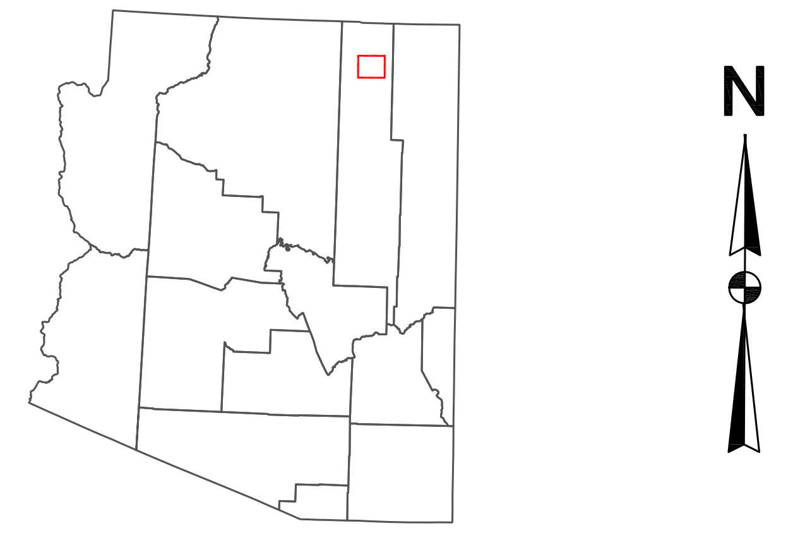
TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN A
SPOIL/SOIL MIXED WITH VEGETATION
(NOT DRAWN TO SCALE)



TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN B
GRAVEL MIXED WITH VEGETATION
(NOT DRAWN TO SCALE)



TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN C
(NOT DRAWN TO SCALE)



REVISION	REV'D BY	DATE

NOTES:
1) For channel locations, see Map 6.1.B, (Sheet 1 of 3).
2) Channel profiles shown are for released areas only.

ENGINEER'S CERTIFICATION

Registered Professional Engineer (Civil)
Certificate No. 37842
GARY ALTSISI
ARIZONA, USA
Date signed: 06/18/19
EXPIRES: 09/30/2020

Gary Altsisi
ARIZONA P.E. 37842

KAYENTA MINE
Peabody
P.O. BOX 650
KAYENTA, ARIZONA 86033

MAP 6.1.B (SHEET 3 OF 3)
N-14 CHANNEL PROFILES

DESIGNED BY: G.A
DRAWN BY: G.E
APPROVED BY: G.A.
COUNTRY: USA
STATE/PROVINCE: ARIZONA
GCS: DATUM/Projection
DATE: 2019-06-18
SCALE: 1" = 50'
DRAWING/SHEET: 3 of 3
C.I.:

0 50 100 150 FEET

LEGEND

—	DRAINAGE	🟦	PROPOSED T.O.J. AREA
—	Tc – CHANNEL FLOW	🟧	APPROVED PHASE I AREA
—	TERRACE CHANNEL	▨	RIPRAP SECTION OF CHANNELS
—	WATERSHED BOUNDARY	▨	GRAVEL SECTION OF CHANNELS
—	PROFILE CHANNEL	(6975)	ELEVATION POINT ON CHANNEL

ENGINEER'S CERTIFICATION

Registered Professional Engineer (Civil)
CERTIFICATE NO. 37842
GARY ALTSISI
ARIZONA, USA
06/18/19

EXPIRES: 09/30/2020

Gary Altsisi
ARIZONA P.E. 37842

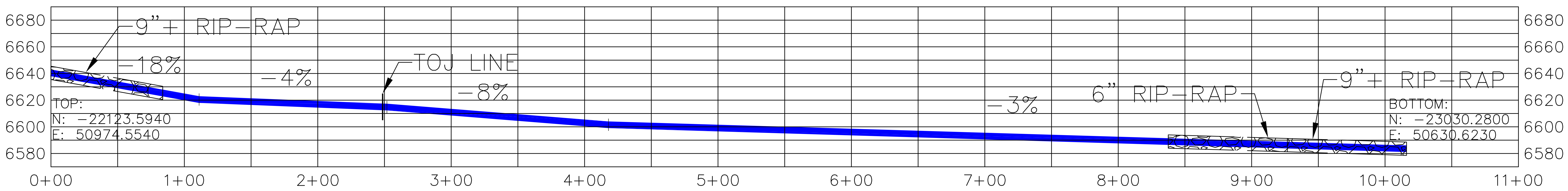
REVISION	REV'D BY	DATE

KAYENTA MINE
Peabody
P.O. BOX 650
KAYENTA, ARIZONA 86033

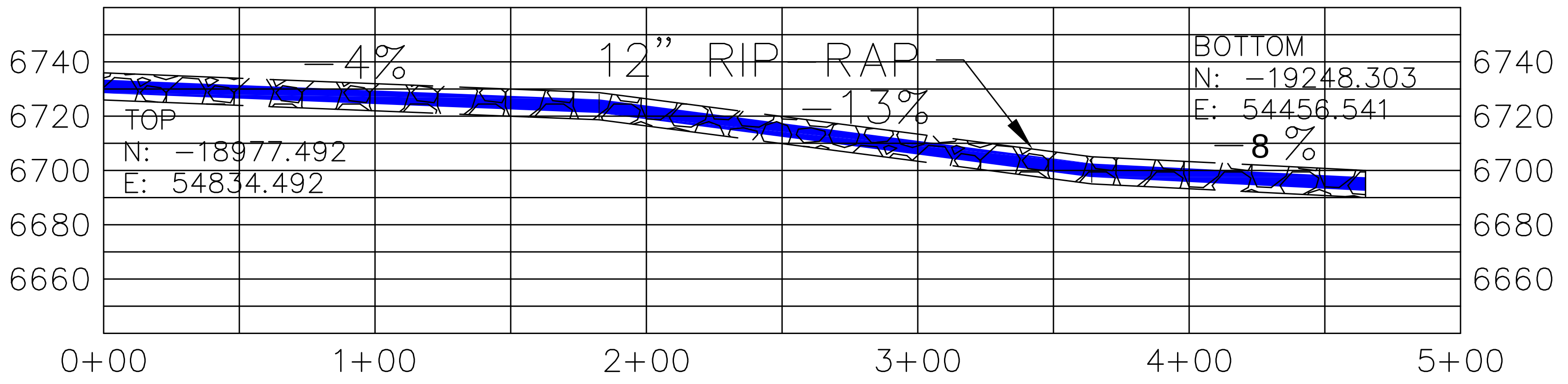
MAP 6.1.B (SHEET 1 OF 3)
N-14 HYDROLOGY PARAMETERS

DESIGNED BY:	G.A	COUNTRY:	USA
DRAWN BY:	G.E	STATE:	ARIZONA
APPROVED BY:	G.A.	PHOTO DATE:	2004-01-25
DATE:	2019-06-18	DRAWING/SHEET:	1 of 6
SCALE:	1" = 400'	C.I.:	5'

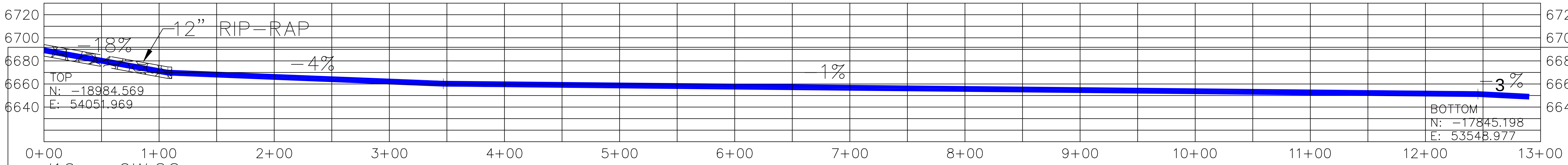
0 400 800 1600 FEET



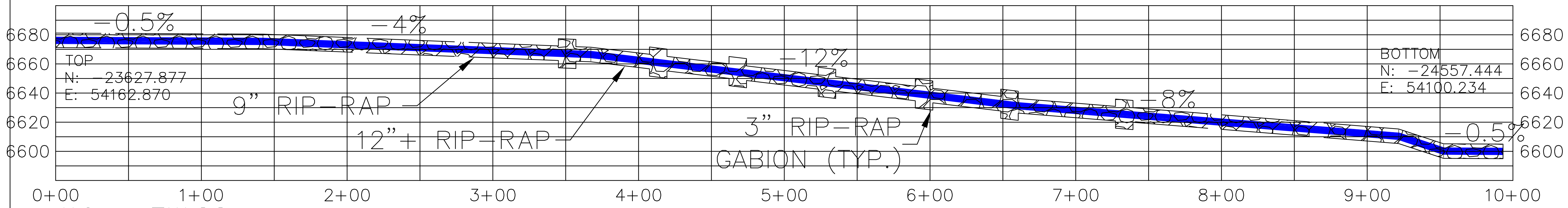
J16 – 6W.1C



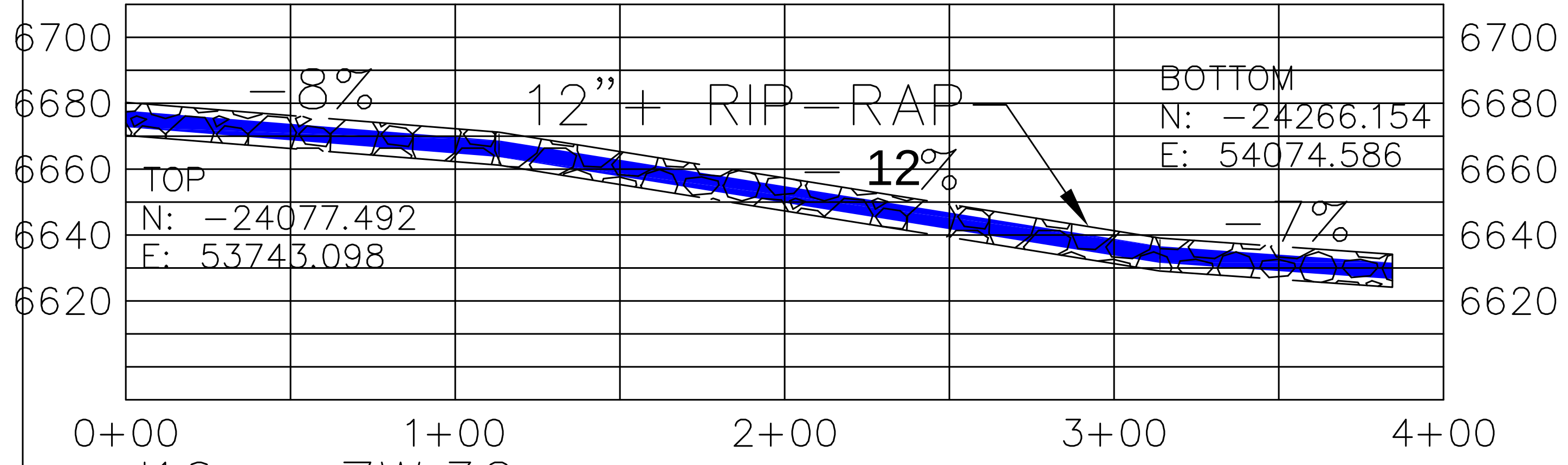
J16 – 6W.1C.1D



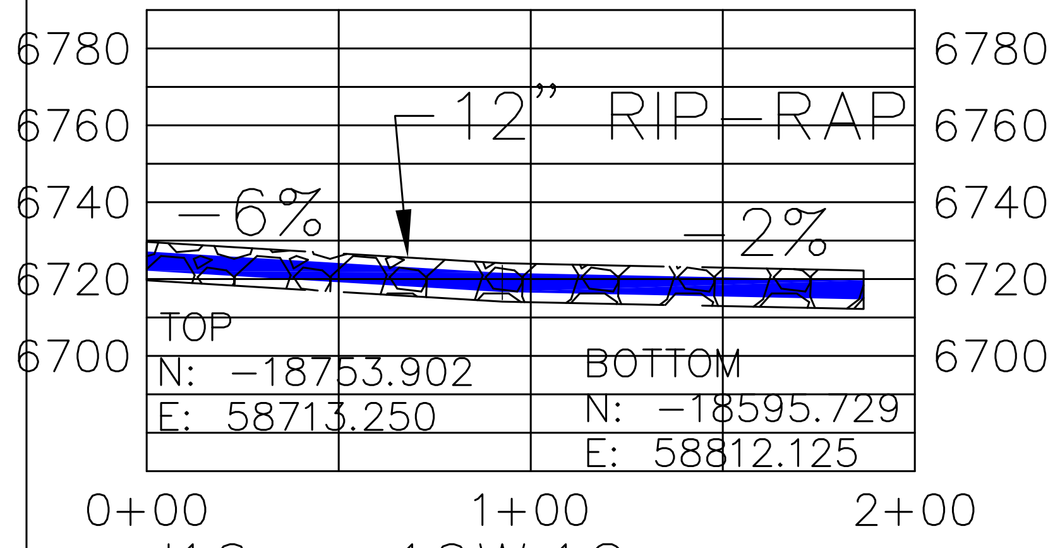
J16 – 6W.2C



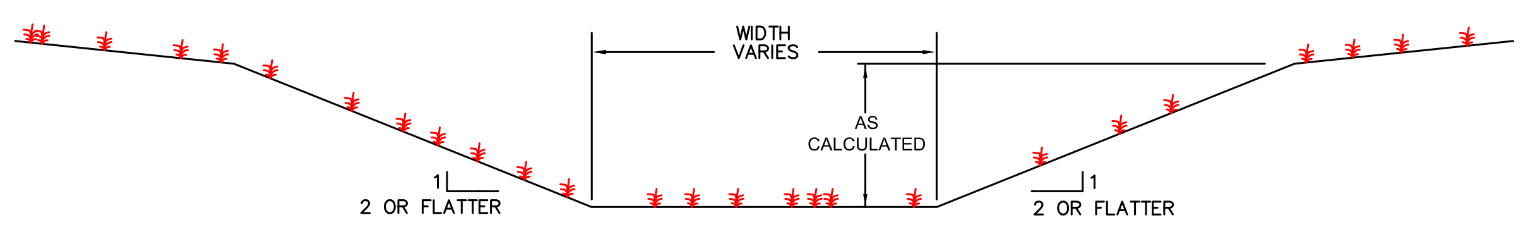
J16 – 7W.2C



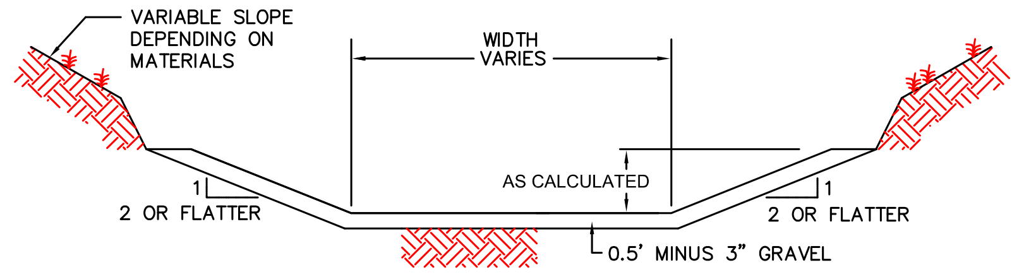
J16 – 7W.3C



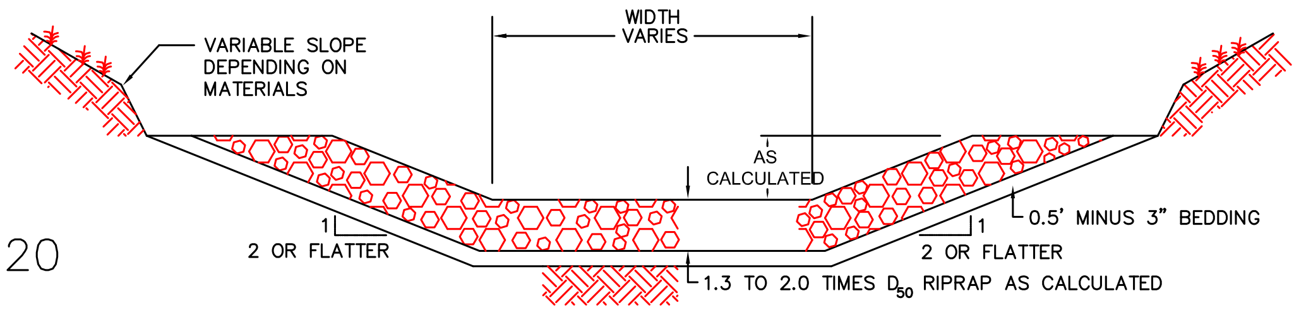
J16 – 10W.1C



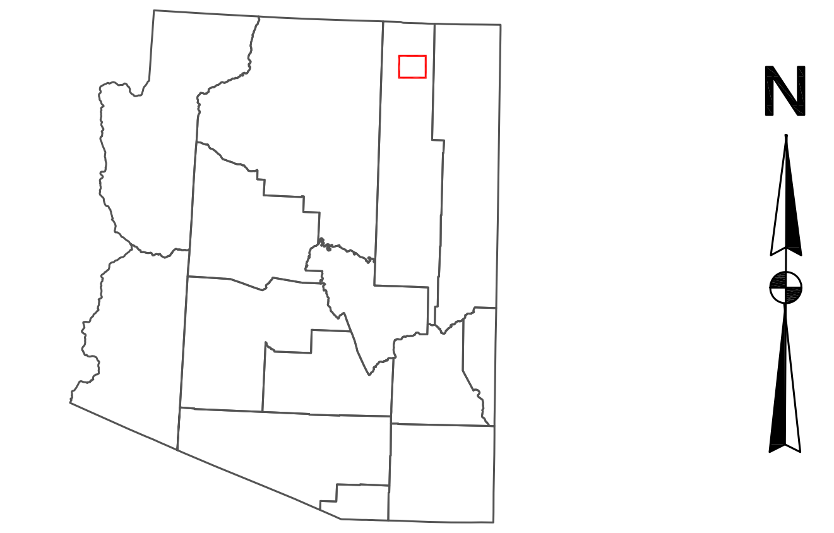
TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN A
SPOIL/SOIL MIXED WITH VEGETATION
(NOT DRAWN TO SCALE)



TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN B
GRAVEL MIXED WITH VEGETATION
(NOT DRAWN TO SCALE)



TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN C
(NOT DRAWN TO SCALE)



REVISION	REV'D BY	DATE

NOTES:
1) For channel locations, see Map 6.1.B, (Sheet 1 of 4).
2) Channel profiles shown are for released areas only.

ENGINEER'S CERTIFICATION

37842
GARY ALTSISI
06/18/19
EXPIRES: 09/30/2020

Gary Altsisi
ARIZONA P.E. 37842

Peabody

KAYENTA MINE
P.O. BOX 650
KAYENTA, ARIZONA 86033

MAP 6.1.C (SHEET 2 OF 4)
J-16 CHANNEL PROFILES

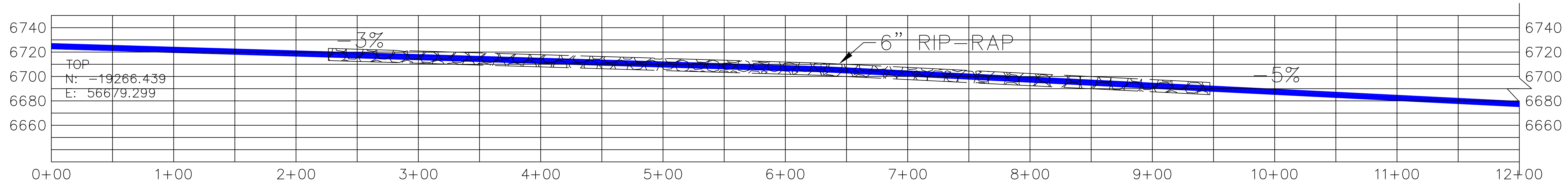
DESIGNED BY: G.A
DRAWN BY: G.E
APPROVED BY: G.A.

COUNTRY: USA
STATE/PROVINCE: ARIZONA
GCS: DATUM/Projection

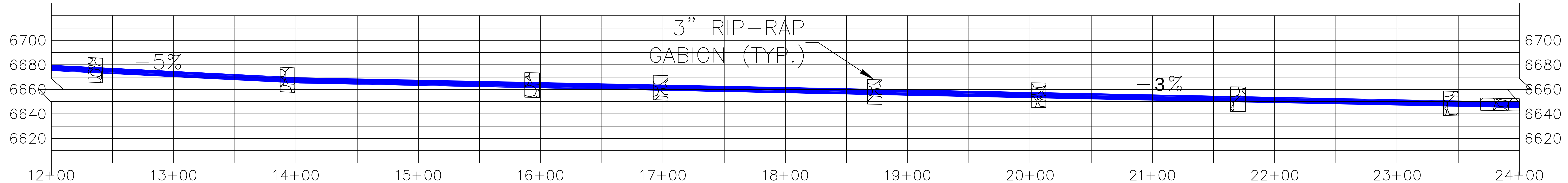
DATE: 2019-06-18
SCALE: 1" = 50'

DRAWING/SHEET: 2 of 4
C.I.:

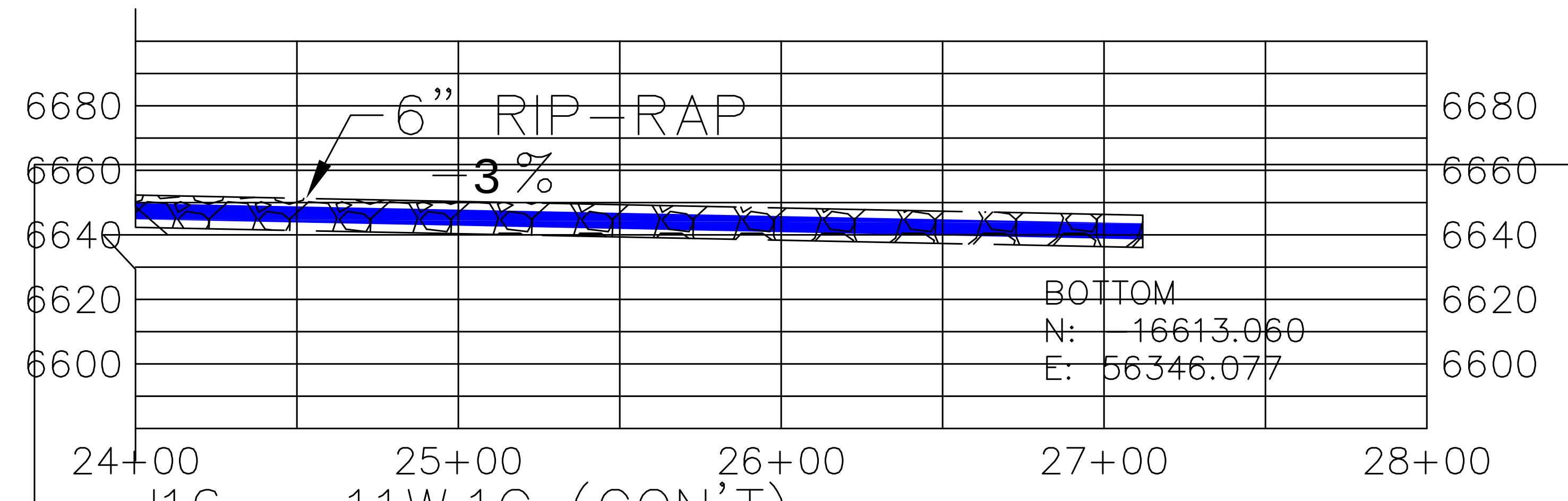
0 50 100 150 FEET



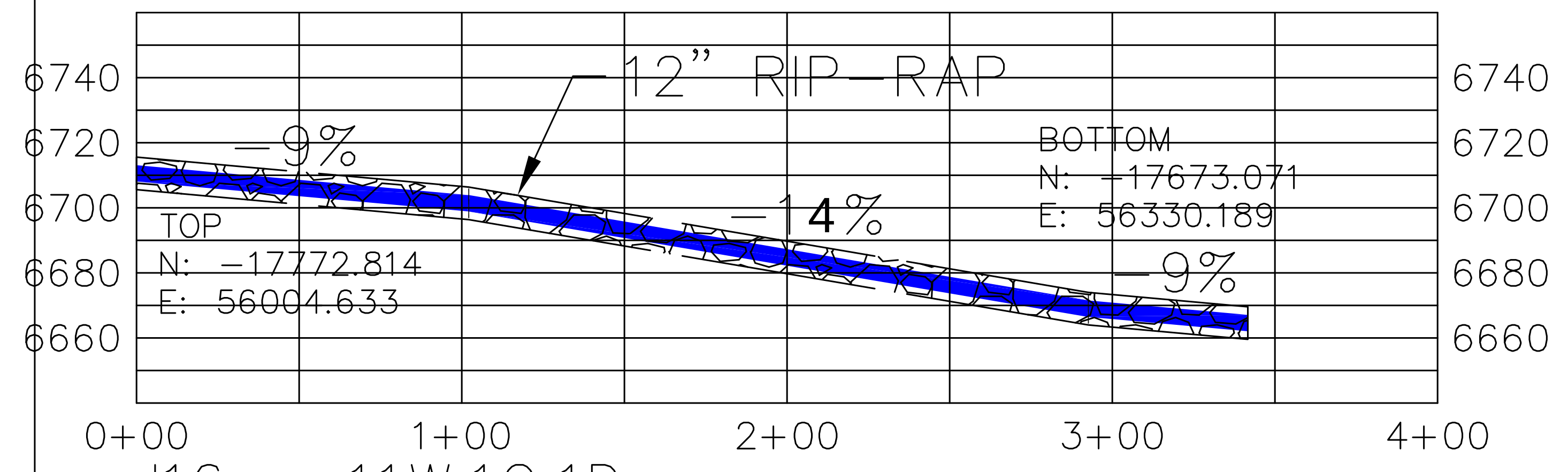
J16 – 11W.1C



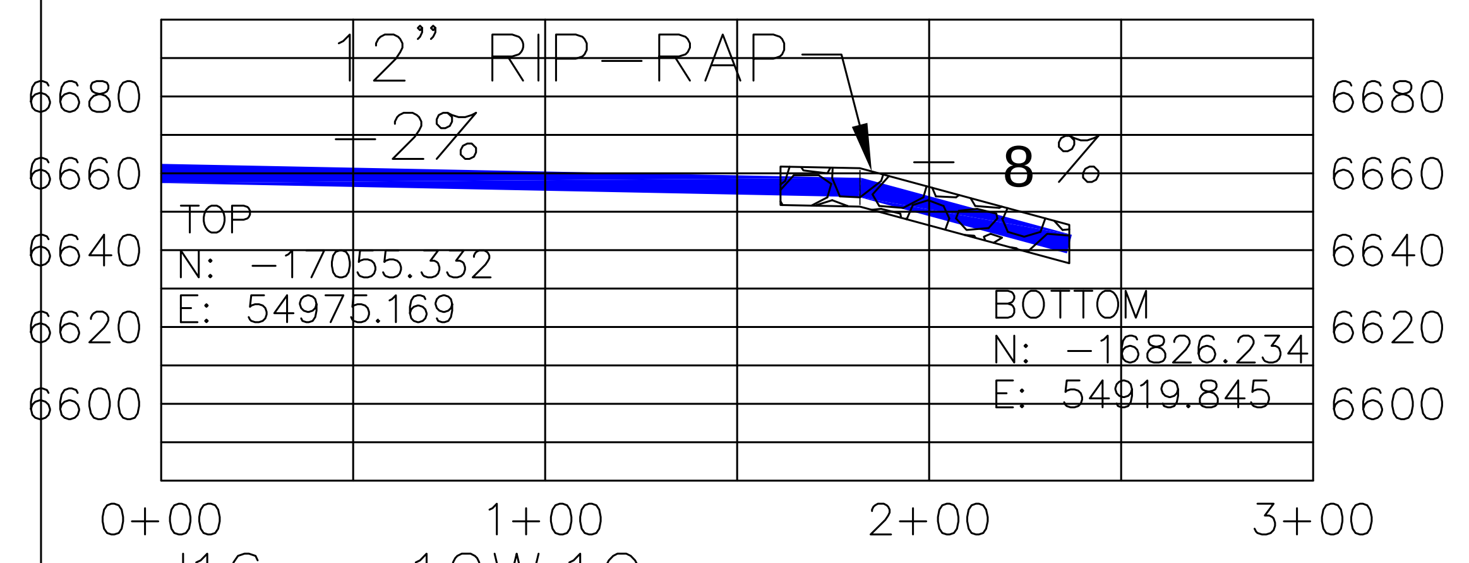
J16 – 11W.1C (CON'T)



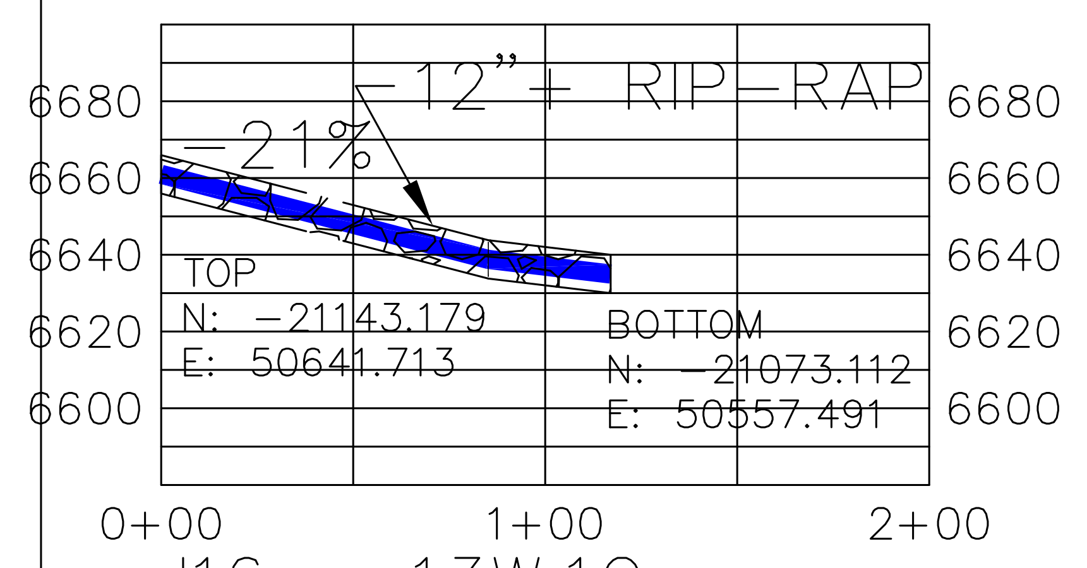
J16 – 11W.1C (CON'T)



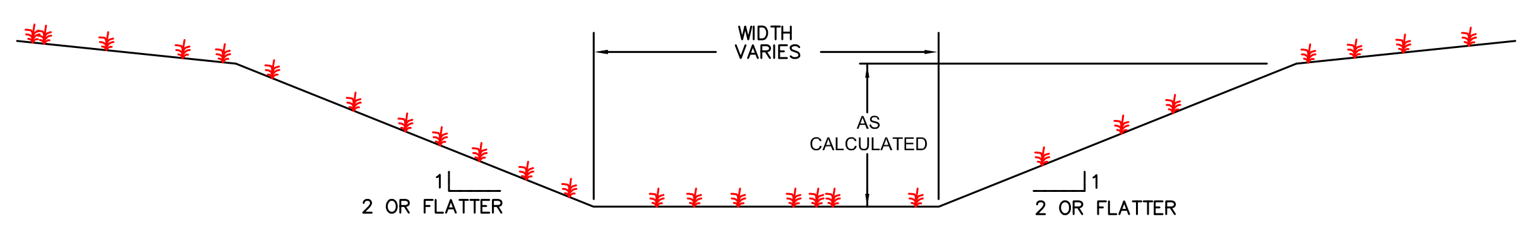
J16 – 11W.1C.1D



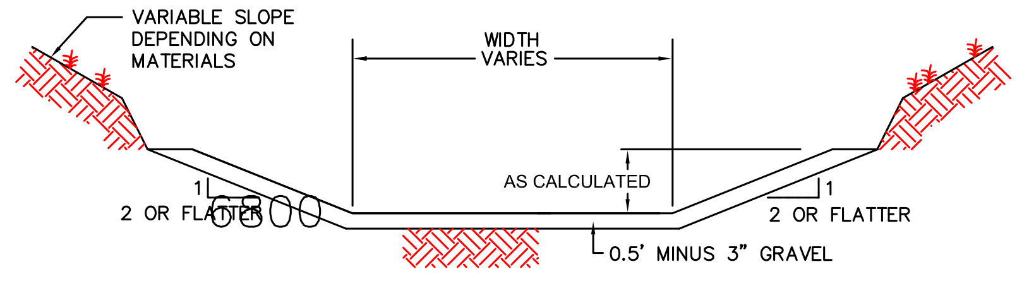
J16 – 12W.1C



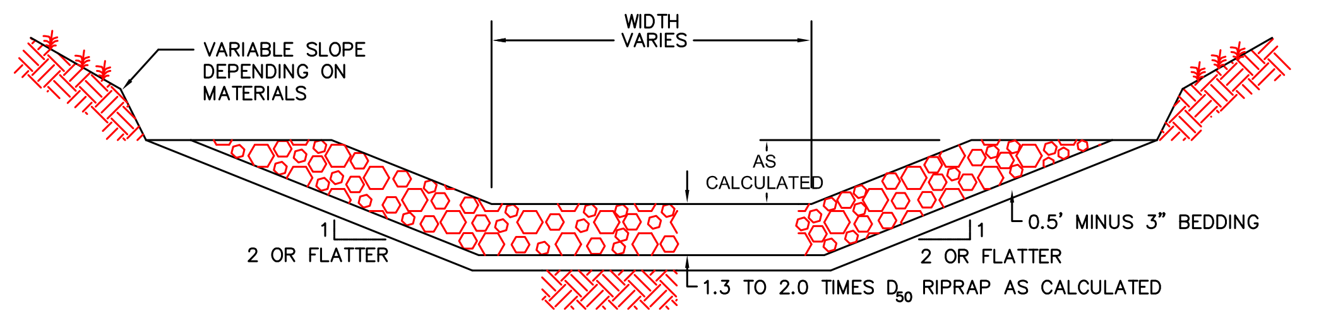
J16 – 13W.1C



TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN A
SPOIL/SOIL MIXED WITH VEGETATION
(NOT DRAWN TO SCALE)



TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN B
GRAVEL MIXED WITH VEGETATION
(NOT DRAWN TO SCALE)



TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN C
(NOT DRAWN TO SCALE)

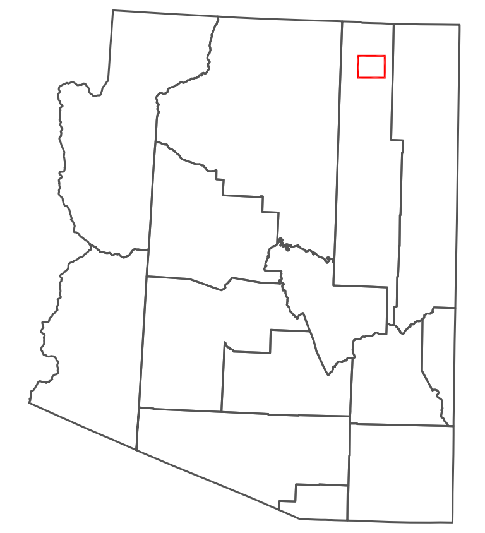
NOTES:
1) For channel locations, see Map 6.1.B, (Sheet 1 of 4).
2) Channel profiles shown are for released areas only.

ENGINEER'S CERTIFICATION

37842
GARY ALTSISI
06/18/19

EXPIRES: 09/30/2020

Gary Altsisi
ARIZONA P.E. 37842



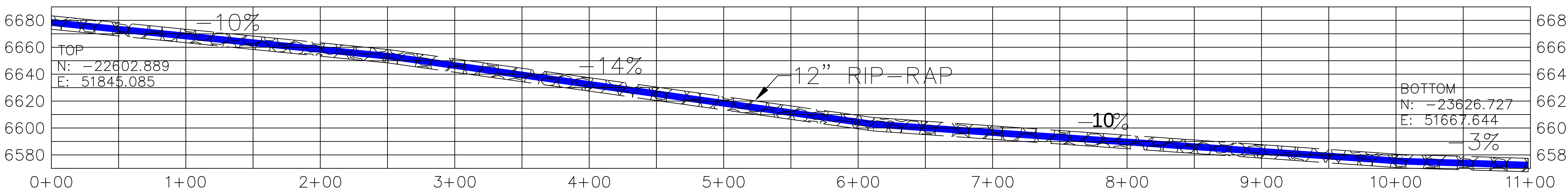
REVISION	REV'D BY	DATE

KAYENTA MINE
Peabody
P.O. BOX 650
KAYENTA, ARIZONA 86033

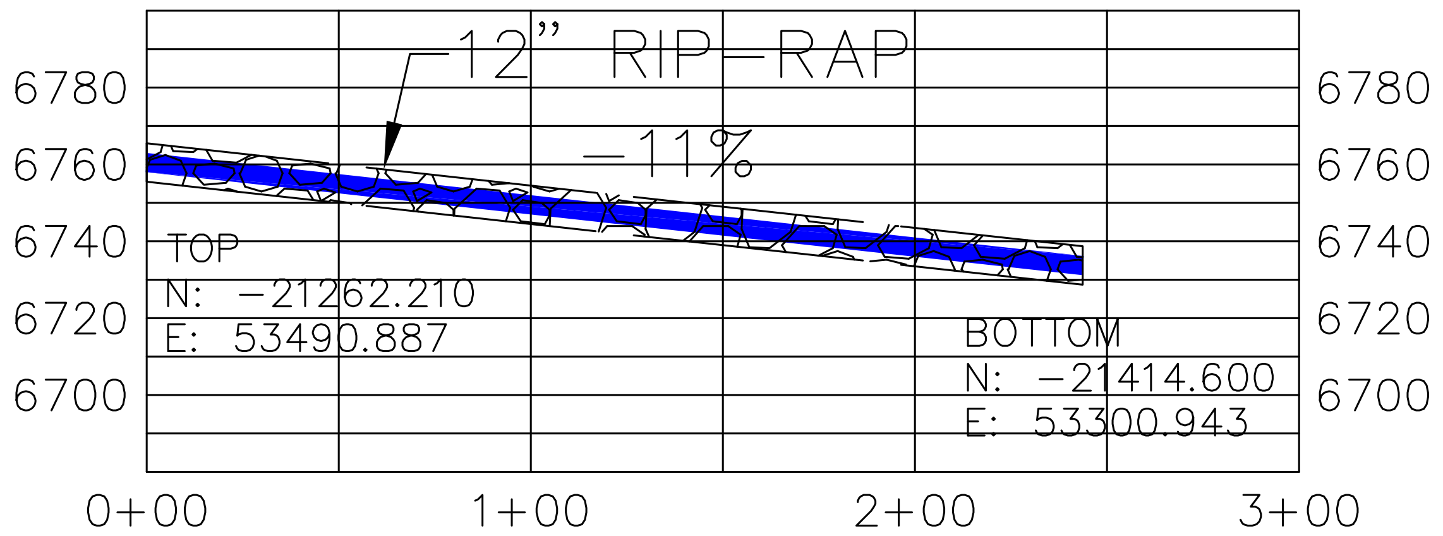
MAP 6.1.C (SHEET 3 OF 4)
J-16 CHANNEL PROFILES

DESIGNED BY: G.A
DRAWN BY: G.E
APPROVED BY: G.A.
COUNTRY: USA
STATE/PROVINCE: ARIZONA
GCS: DATUM/Projection
DATE: 2019-06-18
SCALE: 1" = 50'
DRAWING/SHEET: 3 of 4
C.I.:

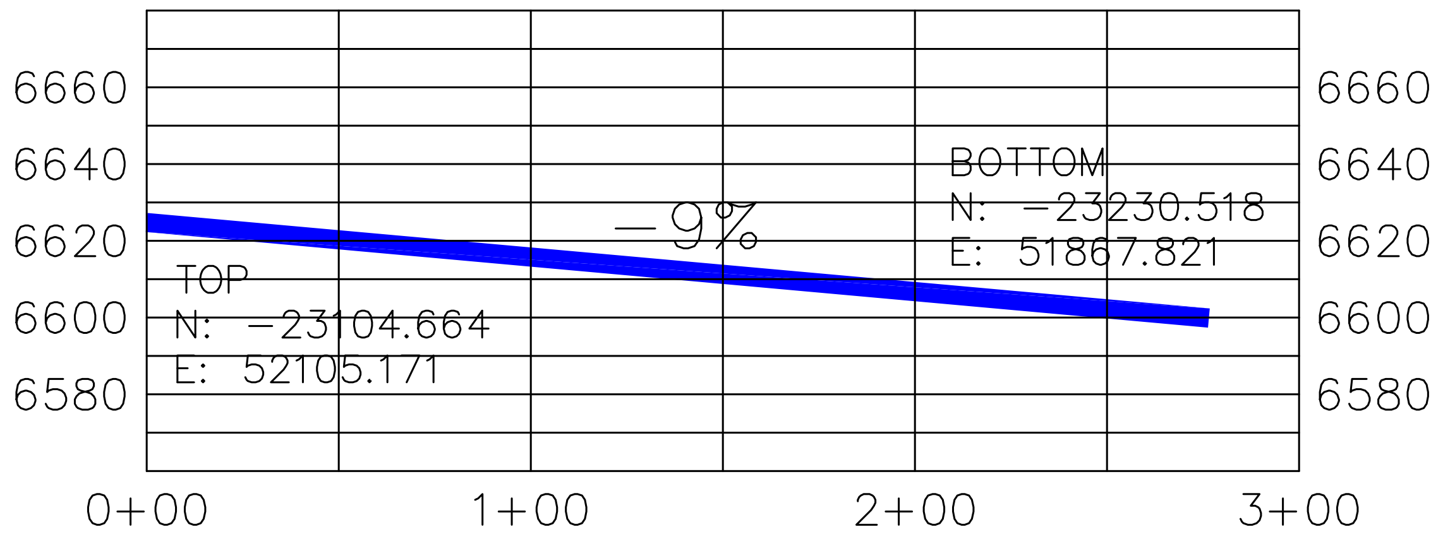
0 50 100 150 FEET



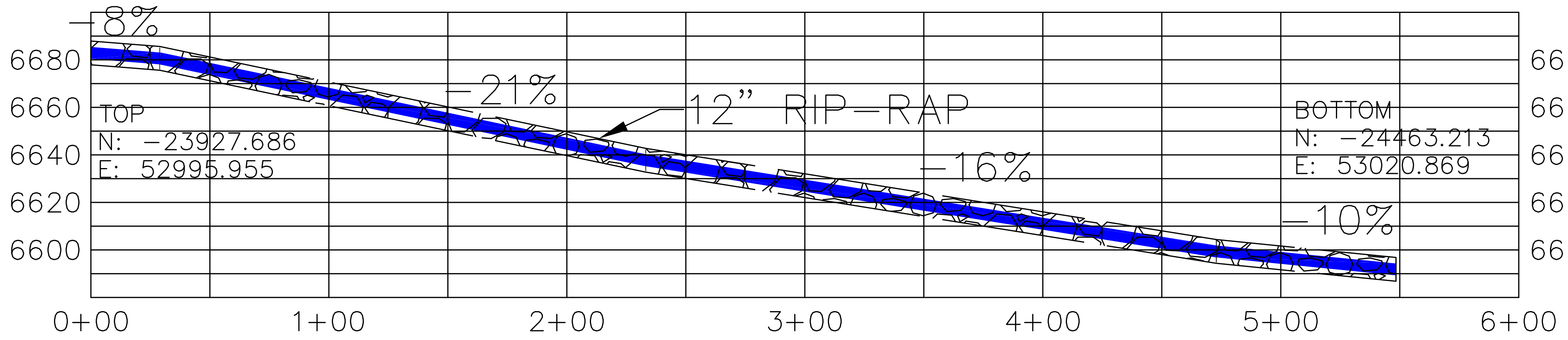
J16 – 14W.1C



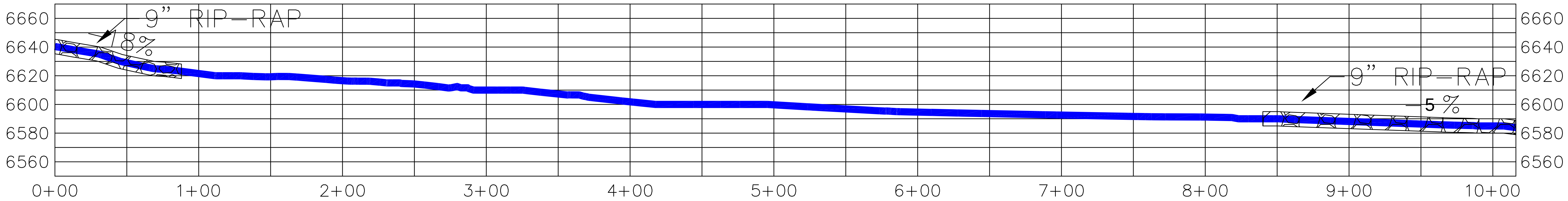
J16 – 14W.1C.1D



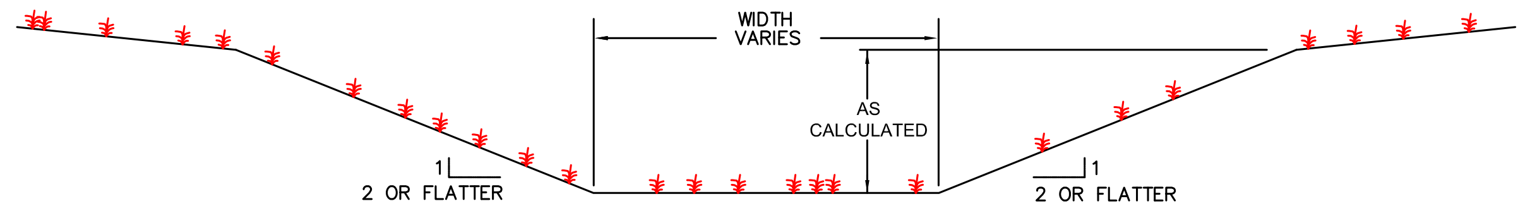
J16 – 14W.2C



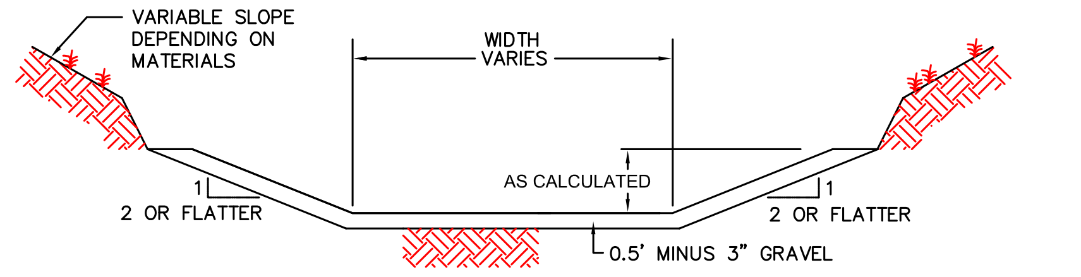
J16 – 15W.1C



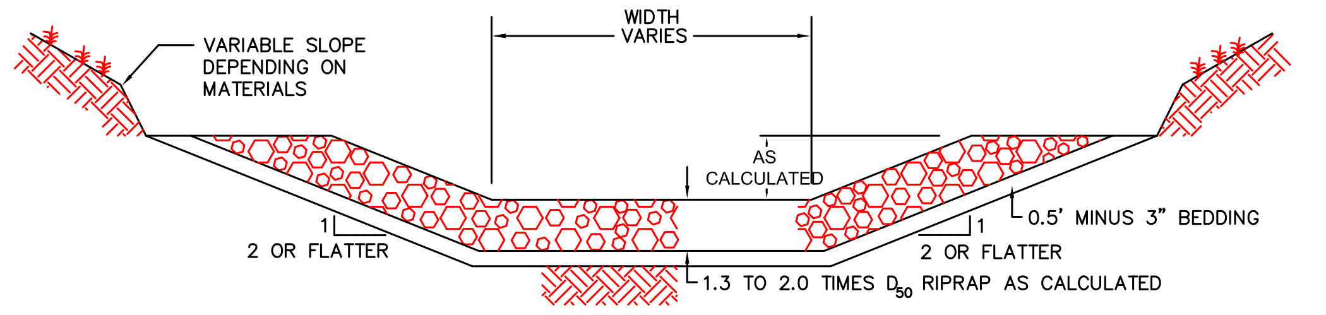
J16 – 9W.1C



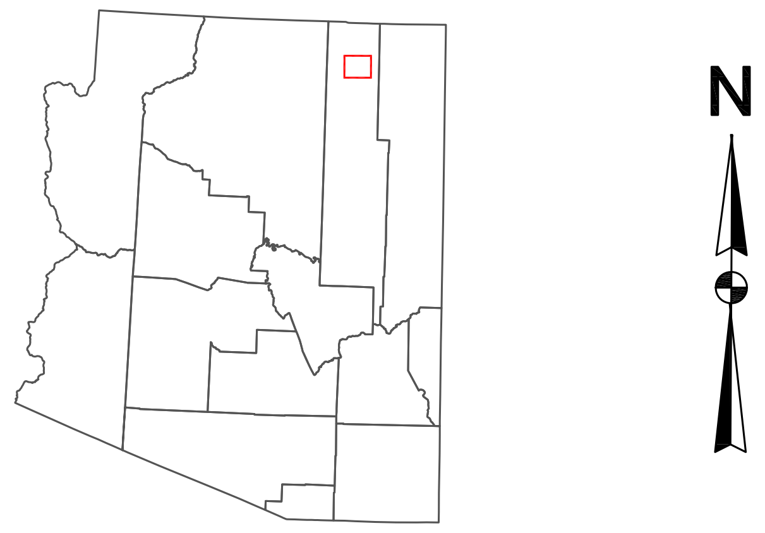
TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN A
SPOIL/SOIL MIXED WITH VEGETATION
(NOT DRAWN TO SCALE)



TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN B
GRAVEL MIXED WITH VEGETATION
(NOT DRAWN TO SCALE)



TYPICAL SECTION OF RECLAIMED TRAPEZOIDAL CHANNEL
DESIGN C
(NOT DRAWN TO SCALE)



REVISION	REV'D BY	DATE

NOTES:
1) For channel locations, see Map 6.1.B, (Sheet 1 of 4).
2) Channel profiles shown are for released areas only.

ENGINEER'S CERTIFICATION

Registered Professional Engineer (Civil)
CERTIFICATE NO. 37842
GARY ALTSISI
Date signed: 06/18/19
ARIZONA, USA

EXPIRES: 09/30/2020

Gary Altsisi
ARIZONA P.E. 37842

KAYENTA MINE
Peabody
P.O. BOX 650
KAYENTA, ARIZONA 86033

MAP 6.1.C (SHEET 4 OF 4)
J-16 CHANNEL PROFILES

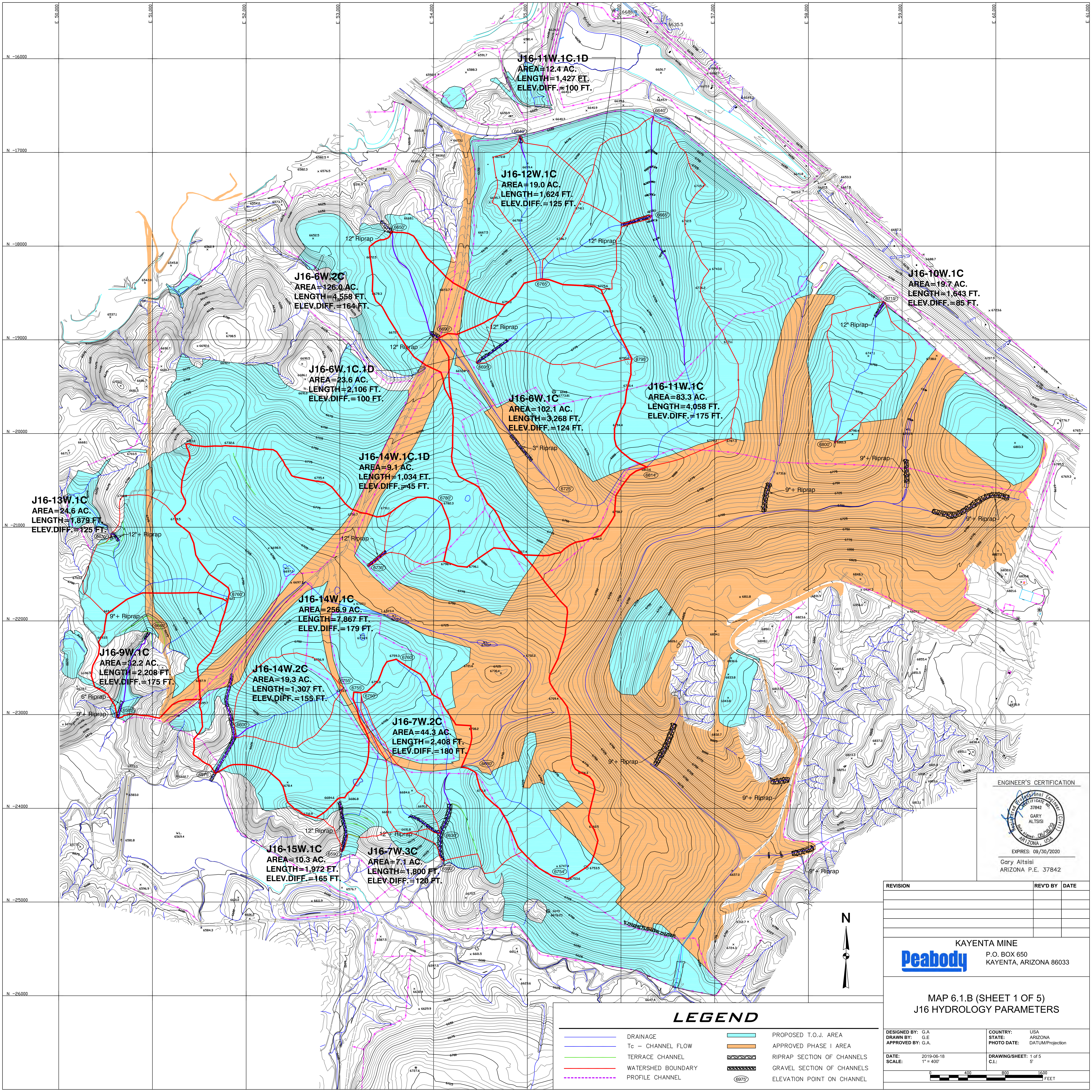
DESIGNED BY: G.A
DRAWN BY: G.E
APPROVED BY: G.A.

COUNTRY: USA
STATE/PROVINCE: ARIZONA
GCS: DATUM/Projection

DATE: 2019-06-18
SCALE: 1" = 50'

DRAWING/SHEET: 4 of 4
C.I.:

0 50 100 150 FEET



LEGEND

─	DRAINAGE	🟦	PROPOSED T.O.J. AREA
─	Tc – CHANNEL FLOW	🟧	APPROVED PHASE I AREA
─	TERRACE CHANNEL	▨	RIPRAP SECTION OF CHANNELS
─	WATERSHED BOUNDARY	▨	GRAVEL SECTION OF CHANNELS
- - -	PROFILE CHANNEL	(6975')	ELEVATION POINT ON CHANNEL

ENGINEER'S CIRTIFICATION

37842
GARY ALTSISI
Date signed: 06/18/19

EXPIRES: 09/30/2020

Gary Altsisi
ARIZONA P.E. 37842

REVISION	REV'D BY	DATE

KAYENTA MINE

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MAP 6.1.B (SHEET 1 OF 5)
J16 HYDROLOGY PARAMETERS

DESIGNED BY: G.A
DRAWN BY: G.E
APPROVED BY: G.A.

COUNTRY: USA
STATE: ARIZONA
PHOTO DATE: DATUM/Projection

DATE: 2019-06-18
SCALE: 1" = 400'

DRAWING/SHEET: 1 of 5
C.I.: 5'

0 400 800 1600 FEET