ANNUAL REPORT FOR 2000

Haws Run Mitigation Site

Pender and Onslow County

Project No. 6.259002T

TIP No. R-2405WM

Prepared By:
Natural Systems Unit & Roadside Environmental Unit
North Carolina Department of Transportation
December 2000

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

SUMMARY

The following report summarizes the monitoring activities that have occurred in the past year at Haws Run Mitigation Site. This site was constructed in 1998 and planted in early 1999. This is the second year of monitoring after site construction. The site must demonstrate both hydrologic and vegetation success for a minimum of three years.

Restoration activities at Haws Run included swamp forest and pine savanna restoration, enhancement, and preservation components. The site is equipped with 25 groundwater monitoring gauges, 2 surface gauges, and one rain gauge. The on-site rain gauge was installed in July 2000; therefore local climate office data is used along with the on-site data to provide complete data for the entire growing season.

Hydrologic monitoring results are presented by three methods: jurisdictional wetland criteria, average depth to groundwater, and duration of soil saturation.

Based on jurisdictional wetland criteria, the Haws Run mitigation site met hydrologic success for the year 2000. In the swamp forest area, all gauges except two met or exceeded the 12.5% jurisdictional wetland criteria. In the pine savanna area, all the gauges recorded hydroperiods greater than 8% of the growing season, which is an improvement over the 1999 results.

Hydrologic patterns of flooding in the restoration areas across Haws Run Mitigation site followed patterns in the reference areas. The duration of saturation between the restoration gauges and the reference gauges were also very comparable for the swamp and savanna areas. Results at the haul road area were variable between the reference and restoration areas and within each area.

Vegetation monitoring consists of three 500 feet X 500 feet sample plots in the savanna areas, and seven 50 feet X 50 feet sample plots within the bottomland hardwood area. Vegetation success criteria was met for 2000, with 31 trees per acre in the savanna area and 459 trees per acre in the swamp forest area. Pond cypress was planted in the savanna area Spring 2000.

The eroded areas on the northern slope were repaired as described in the attached plan. The as-built report and a revised debit ledger will be provided when finalized.

The adjacent land owned by The Nature Conservancy is being pursued for wetland mitigation, potentially providing both hydrologic and habitat benefits.

NCDOT will continue to monitor the hydrology and vegetation on the Haws Run Mitigation site to demonstrate successful achievement of the mitigation plan.

1.0 INTRODUCTION

1.1 Project Description

The Haws Run Mitigation Site was purchased in 1995 by the North Carolina Department of Transportation (NCDOT) to provide compensatory mitigation for unavoidable impacts to wetlands resulting from highway construction in the region. The site is located approximately 28 miles northeast of Wilmington, North Carolina, straddling the Pender-Onslow County line. The site consists of riverine swamp forests at the northern and southern ends and a cutover interior of former wet flats and savannas with an extensive ditch and canal system. The central canal and lateral ditches north of the electrical transmission line were plugged in December 1997 for a short –term study to determine effects of ditch-plugging and filling.

Full site construction began in Summer 1998 with excavation of the northern end of the site to the reference swamp elevation and plugging/filling of the central canal and lateral field ditches to the north of the powerline crossing. Construction was completed in February 1999 and the site was planted in the early spring 1999.

Final planting of pond cypress in the savanna area occurred in the Spring of 2000. This planting was delayed due to difficulty in obtaining needed quantities of this particular specie.

After the hurricane season in 1999, the northern slope between the swamp forest and savanna was eroded in several locations. A slope repair plan, dated June 8 2000, was developed by Roadside Environmental Unit in cooperation with the Natural Systems Unit, Division Construction personnel, and the United States Army Corps of Engineers (Appendix XX). Five eroded areas were backfilled and stabilized with stone lined swales. Two areas were stabilized with seeding and matting. A low berm was constructed to direct overland flow into the stabilized swales. This slope constitutes the transition zone between the swamp restoration area and the savanna restoration area. No wetland mitigation credit is expected from this zone. As-builts of the repair area and a revised debit map are being prepared for submittal.

The adjacent land owned by The Nature Conservancy is being evaluated for potential wetland mitigation. The site consists of approximately 720 acres, including clear cuts, natural forests, and pine plantations. Several ditches, including the canal along the eastern boundary of Haws Run drain the site. Preliminary investigations are currently underway.

1.2 Purpose

In order to demonstrate successful mitigation, hydrologic and vegetative monitoring must be conducted for a minimum of three consecutive years. Development of the success criteria is discussed in the Haws Run Mitigation Plan. The following report documents the results of the hydrologic and vegetative monitoring activities in the year 2000 at the Haws Run mitigation site.

1.3 Project History

Winter 1997	Pilot Study
Sum 1998 – Winter 1999	Site Construction
Spring 1999	Site Planted (entire site, except pond cypress)
October 1999	Vegetation Monitoring (1 yr.)
March – November 1999	Hydrologic Monitoring
March 2000	Pond Cypress Planting Completed
August - October 2000	Slope Repair
October 2000	Vegetation Monitoring (Restart - 1 yr.)
March – November 2000	Hydrologic Monitoring

Figure 1: Vicinity Map

2.0 HYDROLOGY

2.1 Success Criteria

The Haws Run Mitigation Plan, and the Final Responses to Agency Comments, describe the success criteria for hydrology for the site. The success criteria for the swamp restoration area are based on the hydrologic regime of Sandy Run Swamp reference area. Specifically, the mean depth to groundwater for wells in the swamp restoration area should be at, above, or no more than 25% deeper than the mean depth to groundwater for wells in the reference area.

The success criteria for the pine savanna restoration area were initially tied to the Lanier Quarry Savanna reference site. Subsequent to review by NCDOT and USACE, Lanier Quarry savanna was deemed unsuitable as a reference site. Therefore, the success criteria for Haws Run savanna restoration area reverted to federal guidelines for wetlands as described in the 1987 USACE Wetlands Delineation Manual. These guidelines state that the area must be inundated or saturated (within 12" of the surface) by surface or ground water for a consecutive 12.5% of the growing season. Areas inundated less than 5% of the growing season are always classified as non-wetlands. Areas inundated between 5% - 12.5% of the growing season can be classified as wetlands depending upon factors such as the presence of hydrophytic vegetation and hydric soils.

Success criteria for the area isolated by the forestry haul road was based on reestablishing the hydrologic connection of the area to the southern swamp. The flooding regime and groundwater depths should be similar in each area or show recover of these processes after removal of the haul road.

This document uses three methods to report the hydrologic monitoring results for Haws Run mitigation site: jurisdictional wetland criteria, average depth to groundwater, and duration of soil saturation.

The growing season for Haws Run site was calculated as an average of data from Pender County, Onslow County, and the U.S. Weather Bureau publication, *Low Temperature Probabilities in North Carolina.* Using all three data sets, the average growing season for the Haws Run site was estimated to be 237 days in length, lasting from March 23 to November 15. Therefore, for Haws Run to meet the 12.5% jurisdictional wetland hydrology, the water table must not fall below the 12-inch line for at least 30 consecutive days during the growing season under normal precipitation. This hydroperiod is expected in the swamp forest restoration area. The pine savanna restoration area is expected to support jurisdictional wetland hydrology for 8% to 12.5% of the growing season. This translates into a hydroperiod of 19 to 30 consecutive days during the growing season along with the presence of hydrophytic vegetation and hydric soils.

2.2 Hydrologic Description

After site construction, nineteen groundwater monitoring gauges (RDS WL-40) were installed on the site (Figure 2). Two additional gauges, HR-20 and HR-21, were installed in early Spring 2000. HR-15 was reported in the 1999 Monitoring report as located in the delineated wetland in the pine savanna reference area. Using GPS, the location of HR-15 fell in the pine savanna restoration area. This revised location is reported below along with all the gauges located at Haws Run.

- three in the swamp reference area (HR –1, HR-2, HR-4)
- five in the swamp restoration area (HR-3, HR-5, HR-6, HR-21) (HR-19 in the southern swamp restoration area)
- two on the slope transition area (HR-7, HR-8)
- six in the pine savanna restoration area (HR-9 through 12, HR-15, HR-20)
- five in the pine savanna jurisdictional wetlands (HR-13, HR-14, HR-16, HR-17, HR-18)

After field inspection in April 1999, monitoring gauges HR-1 through HR-6 were relocated (as shown on Figure 2) to better represent site conditions. Ground surface elevation was surveyed at each well and used to correlate well data for restoration area and reference area comparisons. Based on similar elevations, the following wells were paired for hydrologic monitoring:

- HR-1 and HR-3 at a relative elevation of 6.2 ft
- HR-2 and HR-5 at a relative elevation of 5.8 ft
- HR-4 and HR-6 at a relative elevation of 4.9 ft

There are also four groundwater gauges, HR-22 through 25, and two surface gauges, SG-1and SG-2, located along the forestry haul road which were installed during the pre-construction monitoring phase. The surface gauges failed to record data properly during this monitoring period and therefore they are not included in this monitoring report. They will be replaced with new gauges. All of the monitoring gauges automatically recorded daily depth to groundwater or surface water on the site. Appendix A contains the graphs for each gauge along with daily rainfall data.

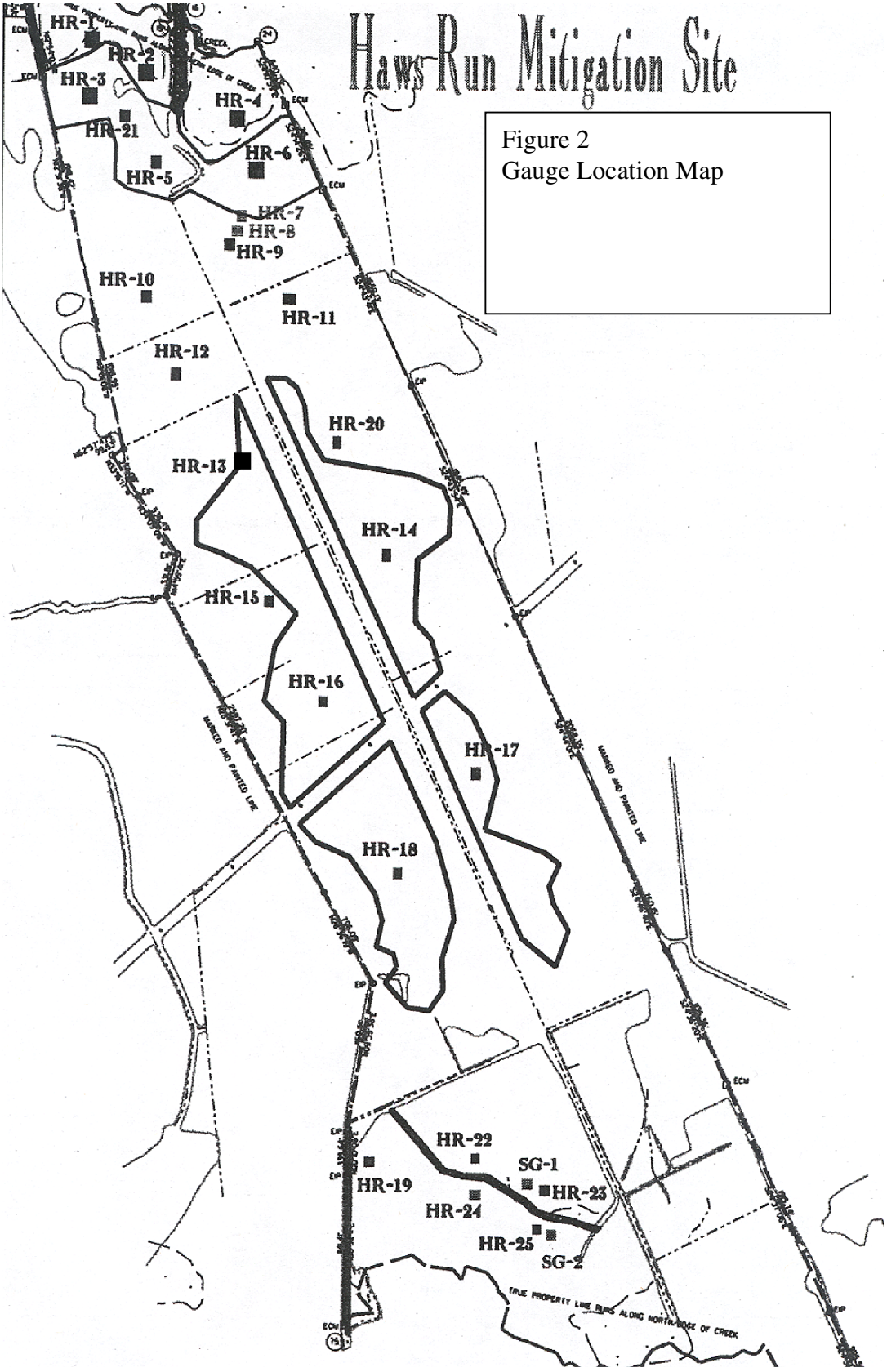


Figure 2
Gauge Location Map

2.3 Results of Hydrologic Monitoring

2.3.1 Site Data

The hydrologic monitoring results from the restoration areas are presented in this report by three methods:

1) Comparison to jurisdictional wetland criteria,
2) Comparison to reference area mean depth to groundwater,
3) Comparison to reference area duration of saturation.

Comparison to Jurisdictional Wetland Criteria

The maximum number of consecutive days that the groundwater was within twelve inches of the surface was determined at each gauge. This number was converted into a percentage of the 237-day growing season. Because of the variability between wetland systems and within wetland types, the monitoring gauge results are segmented into percentage ranges (Figure 3). Table 1 presents the monitoring results for the 2000 growing season as a range of percentages, actual percentages, and success dates of the longest hydroperiod for each gauge on the site. Shaded rows indicate gauges in restoration areas.

Results presented in Table 1 do not include data from the months of July and August. The months of July and August experienced extended periods of rainfall, although monthly totals did not exceed the normal range. Results from this period of extended rainfall are clearly illustrated by the gauge data in Appendix A, showing the response of the groundwater to rainfall.

Three gauges in swamp forest restoration area achieved the optimum hydrology for jurisdictional wetland criteria of 12.5% of the growing season. Gauges HR-5 and HR-21 were slightly below this level, with soil saturation occurring for a consecutive 11.4% and 10.5%, respectively, of the growing season.

In the pine savanna restoration area, three gauges met the 12.5% jurisdictional hydrology criteria. Gauges HR-10 and HR-11 met the 8 – 12.5% jurisdictional hydrology criteria, with soil saturation occurring for a consecutive 10.1% and 10.5%, respectively, of the growing season.

The gauges along the haul road had mixed results. The hydroperiod at HR-22 was well above the 12.5 % criteria. However, the hydroperiod at HR-23 was at 9.7% of the growing season. These results are within the jurisdictional criteria, but vary greatly from each other.

Results from gauges located in the reference areas at Haws Run also supported jurisdictional hydrology for the swamp forest and pine savanna. Gauges in the haul road reference area had mixed results, as did the haul road restoration area.

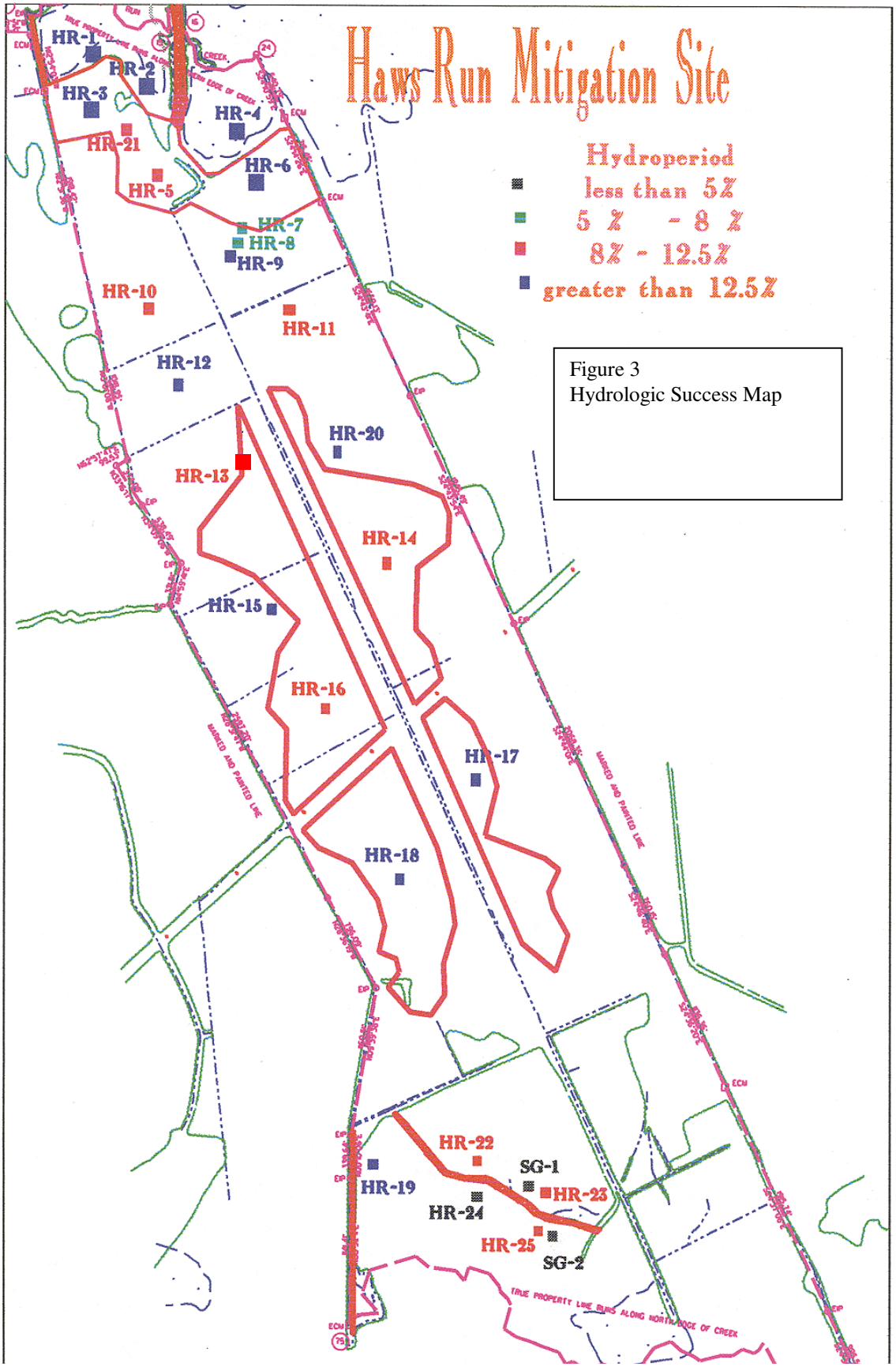


Figure 3
Hydrologic Success Map

Table 1 HYDROLOGIC MONITORING RESULTS

(Not including July – August data)

Monitoring Gauge		< 5%	5% - 8%	8% - 12.5%	> 12.5%	Actual %	Success Dates
SWAMP FOREST	HR-1				✔	24.9	March 23 – May 20
	HR-2				✔	31.2	March 23 –June 13
	HR-3				✔	21.5	March 23- May 12
	HR-4				✔	29.9	March 23 –June 13
	HR-5			✔		11.4	April 15 – May 11
	HR-6				✔	43.9	March 23 – July 4
	HR-19				✔	21.5	March 23 – May 12
	HR-21			✔		10.5	April 15 – May 9
Trans Zone	HR-7			✔		9.3	April 15 – May 6
	HR-8			✔		10.1	April 15 – May 8
PINE SAVANNA	HR-9				✔	21.5	March 23 – May 12
	HR-10			✔		10.1	April 15 – May 8
	HR-11			✔		10.5	April 15 – May 9
	HR-12				✔	23.6	March 23 – May 17
	HR- 20				✔	21.9	March 23 – May 13
	HR-13			✔		10.9	April 15 – May 10
	HR-14			✔		11.4	April 15 – May 11
	HR-15				✔	29.5	Mar 23 – May 31
	HR-16			✔		9.3	April 15 – May 6
	HR-17				✔	24.0	March 23 – May 18
	HR-18				✔	22.8	March 23 -May 15
HAUL ROAD	HR-22				✔	20.2	Mar 23 – May 9
	HR-23			✔		9.7	April 15 –May 7
	HR-24	✔				3.8	April 15 – April 23
	HR-25			✔		9.7	April 15 – May 7

Comparison of Average Depth to Groundwater

The average depth to groundwater for both the reference and restoration area gauges was calculated and plotted for the growing season (Appendix B). Appendix B also contains the comparisons of depth to groundwater for paired gauges. The results are presented as a percentage of the days when the depth to groundwater in the restoration area was at, above, or no deeper than 25% of the depth to groundwater in the reference area. The results are as follows.

- Average Swamp restoration area was comparable for 54% of days in the Average Swamp reference area.
- MW-3: 60% of days at MW-1.
- MW-5: 37% of days at MW-2.

- MW-6: 93% of days at MW-4.

- Average Pine Savanna restoration area was comparable for 79% of days in the Average Pine Savanna reference area.

- Average Haul road restoration area was comparable for 86% of days in the Average Haul road reference area.

Comparison of Duration of Saturation

For each well, the longest hydroperiod i.e., the number of consecutive days of soil saturation (free water table) within 12 inches of the surface, was calculated and averaged for the restoration areas and the reference areas. The average hydroperiod for the restoration area is reported as a percentage of the average hydroperiod for the reference area. The comparison is also made for the paired wells. The results are as follows.

- Average Swamp restoration area hydroperiod was 89% of Average Swamp reference area hydroperiod.
- MW-3: 86% of MW-1.
- MW-5: 36% of MW-2.
- MW-6: 146% of MW-4.

- Average Pine Savanna restoration area hydroperiod was 91.5% of Average Pine Savanna reference area hydroperiod.

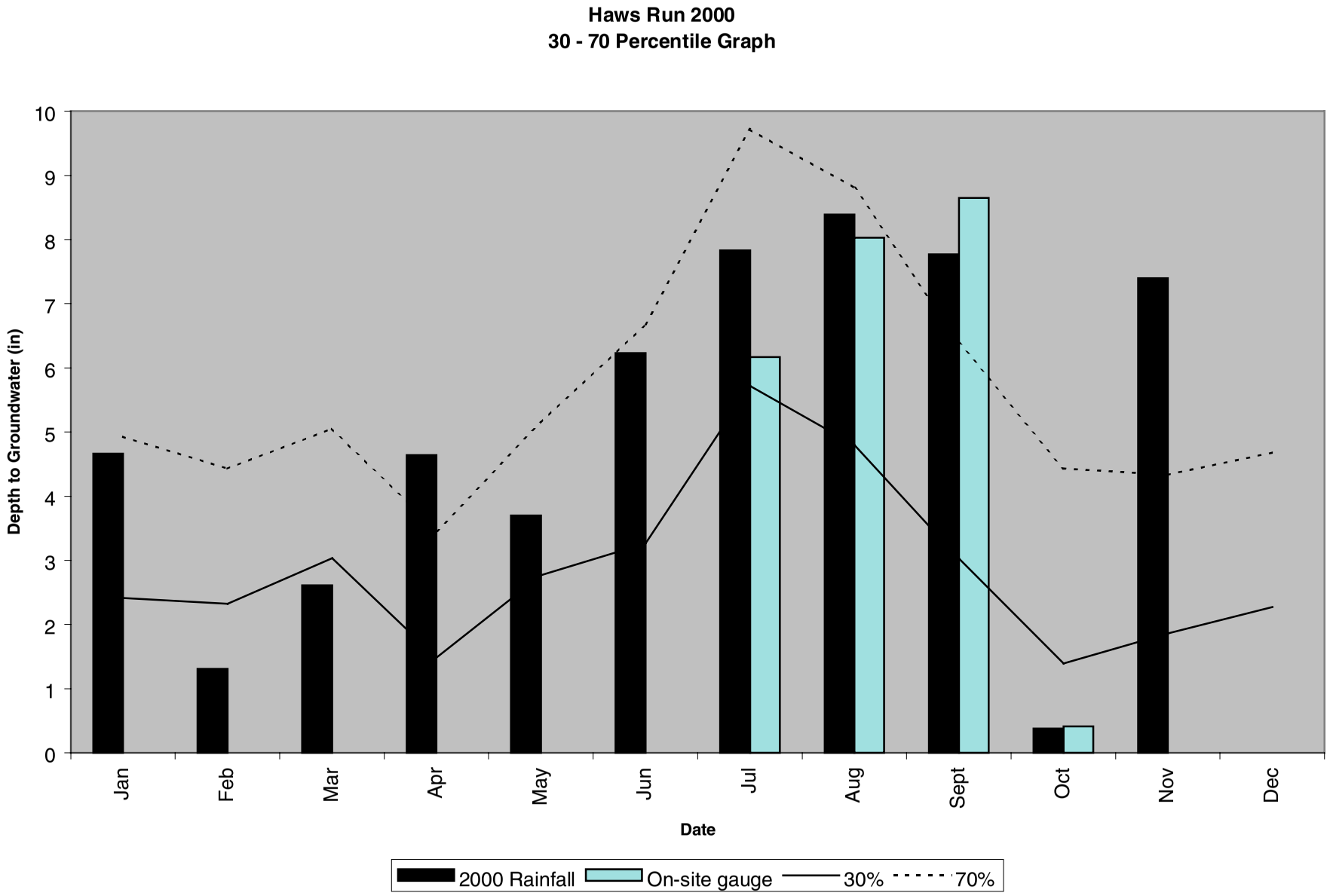
- Average Haul road restoration area hydroperiod was 159% of Average Haul road reference area hydroperiod.

2.3.2 Climatic Data

Figure 4 represents an examination of the local climate in comparison with historical data to determine if 1999 rainfall is within the normal rainfall range of the area. The historical data was provided by the National Climatic Data Center; the recent rainfall data from Wilmington Airport was provided by the State Climate Office at NC State University. Both sets of data were recorded at Trenton, NC. The Trenton station was used in place of the Marine Corp Air Station at New River station because of incomplete data records.

Rainfall during May, June, and August were below the normal range for the area. March, April, and July rainfall fell within the normal range. Data after August were not available.

Figure 4 Monthly Rainfall Totals



2.4 Conclusions

Based on jurisdictional wetland criteria, the Haws Run mitigation site met hydrologic success for the year 2000. In the swamp forest area, all gauges except two met or exceeded the 12.5% jurisdictional wetland criteria. The two exceptions recorded a hydroperiod of approximately 11% of the growing season. These gauges are in a location slightly higher in elevation relative to the other gauges. HR-6 recorded a substantially longer hydroperiod than rest of the swamp area. It is located in a low area of the swamp restoration that receives and holds runoff from the adjacent land. The swamp reference area gauges showed similar results. In the pine savanna area, all the gauges recorded hydroperiods greater than 8% of the growing season, which is an improvement over the 1999 results. The pine savanna reference area at Haws Run also showed results similar to the restoration area. Results at the haul road area were variable between the reference and restoration areas and within each area. The hydroperiods for two gauges were just below 10% of the growing season. The other two gauges represented an extreme high of 20% and an extreme low of 3.8% of the growing season.

Hydrologic patterns in the restoration areas across Haws Run Mitigation site did follow patterns in the reference areas. Flooding frequency and depth in the swamp restoration area coincided with flooding in the swamp reference area. The comparison plots in Appendix B clearly illustrate the restoration hydrologic regime coinciding with the reference area hydrologic regime. The water table did decline quicker in the swamp restoration area than in the swamp reference area, resulting in less storage time. This can be partially attributed to differences in soil organic matter content and surface roughness between the two areas.

Water table fluctuations in the pine savanna area were more variable between gauges. However, average restoration and reference area values were very similar. The plots in Appendix B show the similarities in hydrologic regime between the savanna reference and restoration areas. The daily average depth to groundwater in the pine savanna restoration area matched the reference area 79% of the growing season.

The average hydrologic regime for the haul road restoration area was very similar to the reference area. Although the actual values varied substantially, the flooding patterns coincided very well. The data illustrated the effects of removal of the haul road, reestablishing the hydrologic connection of the isolated area to the southern swamp area.

The duration of saturation between the restoration gauges and the reference gauges were also very comparable for the swamp and savanna areas. The lengths of the hydroperiods for both restoration areas were approximately 90% of the reference area hydroperiods. The restoration gauges in the haul road area

exhibited a much longer hydroperiod than the reference area, attributable mainly to HR-22.

3.0 VEGETATION: HAW'S RUN MITIGATION SITE (YEAR 1 OF 5)

3.1 Success Criteria

A. Savanna Areas

Success Criteria states that there must be a minimum of 20 trees per acre living for at least five consecutive years.

B. Swamp Forest Area

NCDOT will monitor the site for five years. A 320 stems per acre survival criterion for planted seedlings will be used to determine success for the first three years. The required survival criterion will decrease by 10% per year after the third year of vegetation monitoring (i.e., for an expected 290 stems per acre for year 4, and 260 stems per acre for year 5). The number of plants of one species will not exceed 20% of the total number of plants of all species planted.

C. Grass Area

No success criteria were established for the planted grass areas.

3.2 Description of Species

A. Savanna Areas

The following tree species were planted in the Savanna Restoration and Enhancement Areas:

Zone 1: Wet Savanna Restoration and Enhancement Area (202 acres)

Pinus palustris, long-leaf pine

Pinus serotina, pond pine

Taxodiun ascendens, pond cypress

Zone 2: Dry Savanna Enhancement Area (113 acres)

Pinus palustris, long-leaf pine

B. Swamp Forest Area

The following tree species were planted in the Swamp Forest Area:

Zone 3: Swamp Forest Restoration Area (33 acres)

Nyssa sylvatica var. biflora, swamp tupelo

***Taxodium distichum*, bald cypress**

Quercus laurifolia, laurel oak

Quercus lyrata, overcup oak

Quercus michauxii, swamp chestnut oak

Liriodendron tulipfera, tulip poplar

Quercus falcata var. pagodaefolia, cherrybark oak

Fraxinus pennsylvanica, green ash

Platanus occidentalis, sycamore

C. Grass Area

The following grass species were planted in ten 100' x 100' grass plots:

Wiregrass

Carolina dropseed

Toothache grass

Savanna muhly

3.3 Results of Vegetation Monitoring

A. Savanna Areas

ZONE	Plot #	Long-leaf Pine	Pond Pine	Pond Cypress	Total	Density (Tree/Acre)
1	S1	18	85	14	117	21
	S3	104	162	5	271	48
	ZONE 1 AVG.					**34**
2	S2	135			135	24
	ZONE 2 AVG.					**24**
	TOTAL AVG.					**31**

To determine tree density, 500' x 500' plots (5.7 acre) were installed immediately following planting. The actual numbers of planted trees, which occur within the plot, are counted. Since the actual plot size is 5.7 acres, actual trees per acre can be estimated.

Notes from Report: Pines in savanna areas growing well. Broomsedge is present throughout plots. The wet savanna restoration area was planted with pond cypress in Spring 2000. The trees were difficult to find in large plots.

B. Swamp Forest Area

To determine tree density, 50' x 50' plots are installed immediately following planting. The actual numbers of planted trees, which occur within the plot, are counted. This number is equated to the number within each plot, which represents 680 trees per acre (average). The survival monitoring number is compared to the planted number to obtain survival percentage. This percentage is applied to the 680 trees per acre to obtain an estimated tree per acre for the site. (Density = monitoring count / planted trees x 680)

Plot #	Swamp Tupelo	Baldcypress	Pond Cypress	Laurel Oak	Overcup Oak	Swamp Chestnut Oak	Tulip Poplar	Cherrybark Oak	Green Ash	American Sycamore	Total (1 year)	Total (at planting)	Density (Tree/Acre)
1		1			4	1		1	1		8	32	170
2	4	9			5	5		4	15		42	53	539
3	3	2			4	6			6		21	34	420
4	1	3			3	11		3	6		27	35	525
5					19	5		9			33	39	575
6	5			6	3			7	5		26	36	491
7	3	1		4	2	1		3	5	12	31	43	490
TOTAL AVG.													459

Site Notes: Other species noted: rushes, woolgrass. smart weed, black willow, various grasses, juncus, some sweetgum and some red maple. Plot 1 had 6 – 8 inches of water. Trees were difficult to find in plot 3 due to heavy rushes and woolgrass. Plot 7 has had vehicle traffic. Overall, the trees look good. The

higher areas and are predominantly oak species while the lower areas are predominantly bald cypress and swamp tupelo.

C. Grass Area

Only visual inspection was done within the grass plots. Grasses appear to be establishing well.

3.4 Conclusions

A. Savanna Areas

Of the 595 acres of this site, approximately 315 acres involved savanna tree planting. There were 3 test plots established throughout the planting. The vegetation monitoring of the planted areas revealed an average density to be 31 trees per acre, which is well above the minimum requirement of 20 trees per acre.

B. Swamp Forest Area

Of the 595 acres of this site, approximately 33 acres involved tree planting. There were 7 test plots established throughout the planting. The vegetation monitoring of the planted areas revealed an average density to be 459 trees per acre, which is well above the minimum requirement of 320 trees per acre.

The transect areas at the southern end of the site were supplementally planted Spring 2000.

The washouts along the northern side of the site adjacent to the swamp forest area were repaired and are stabilizing.

C. Grass Area

Of the 595 acres of this site, approximately 2.3 acres involved grass planting. The grasses were planted in ten 100' x 100' test plots. The vegetation monitoring of the planted areas revealed that the planted grasses were establishing well.

4.0 OVERALL CONCLUSIONS / RECOMMENDATIONS

Hydrologic monitoring in 2000 revealed trends in the restoration areas similar to those in the reference areas. The majority of gauges on site did meet jurisdictional wetland criteria, as well as exhibit comparable depths to groundwater and duration of the hydroperiods.

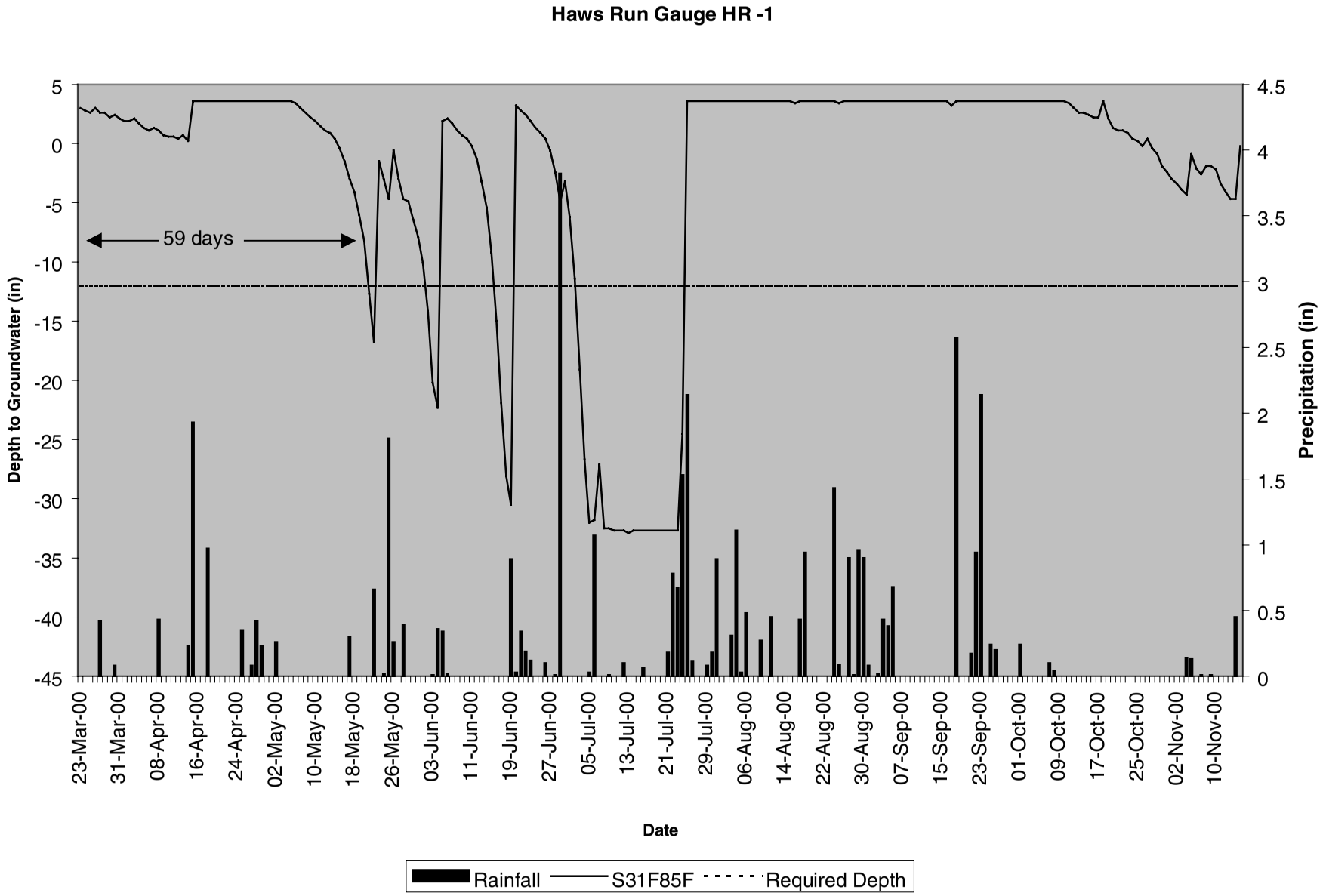
Vegetation on Haws Run is doing well in both the swamp and savanna areas, with exceptions as noted. Final planting was completed Spring 2000.
The erosion areas on the northern slope were repaired as described in the attached plan. The as-built report and revised debit ledger will be submitted after completion.

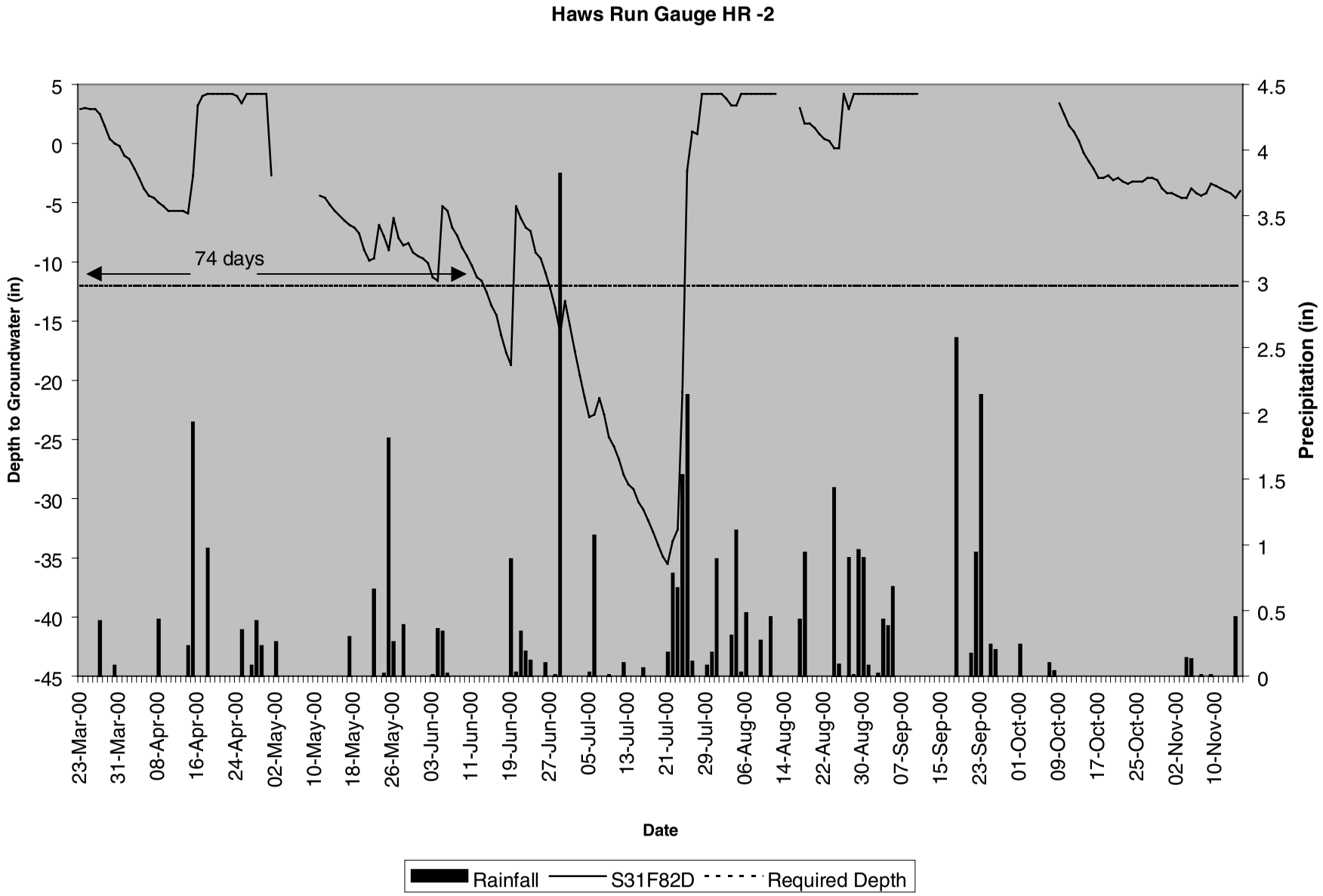
Overall, the Haws Run Mitigation site performed well in 2000. Jurisdictional wetland hydrology was established and supported a prevalence of hydrophytic vegetation.

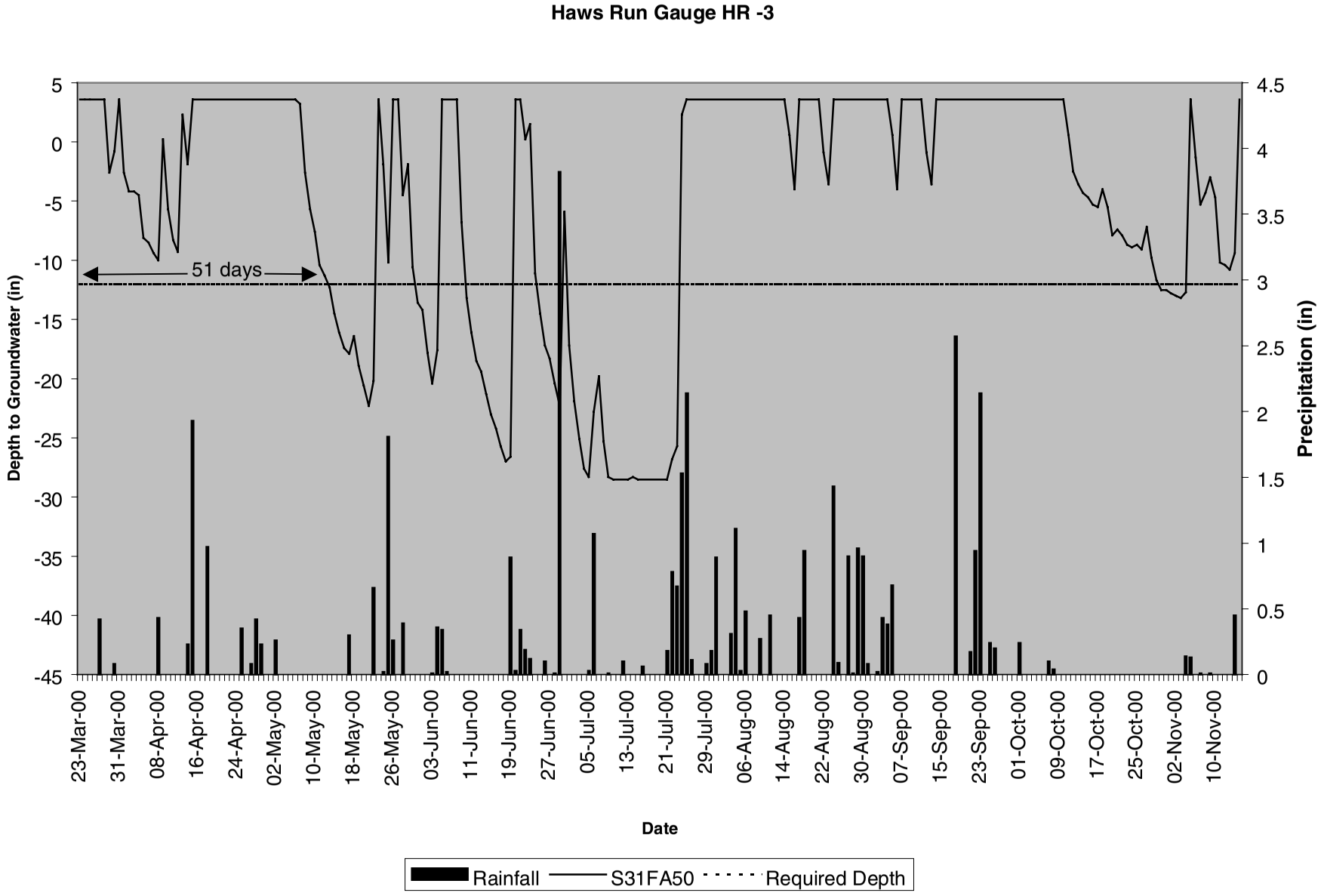
The potential addition of the adjacent Nature Conservancy land to the Haws Run Mitigation site will provide both hydrologic and habitat benefits.

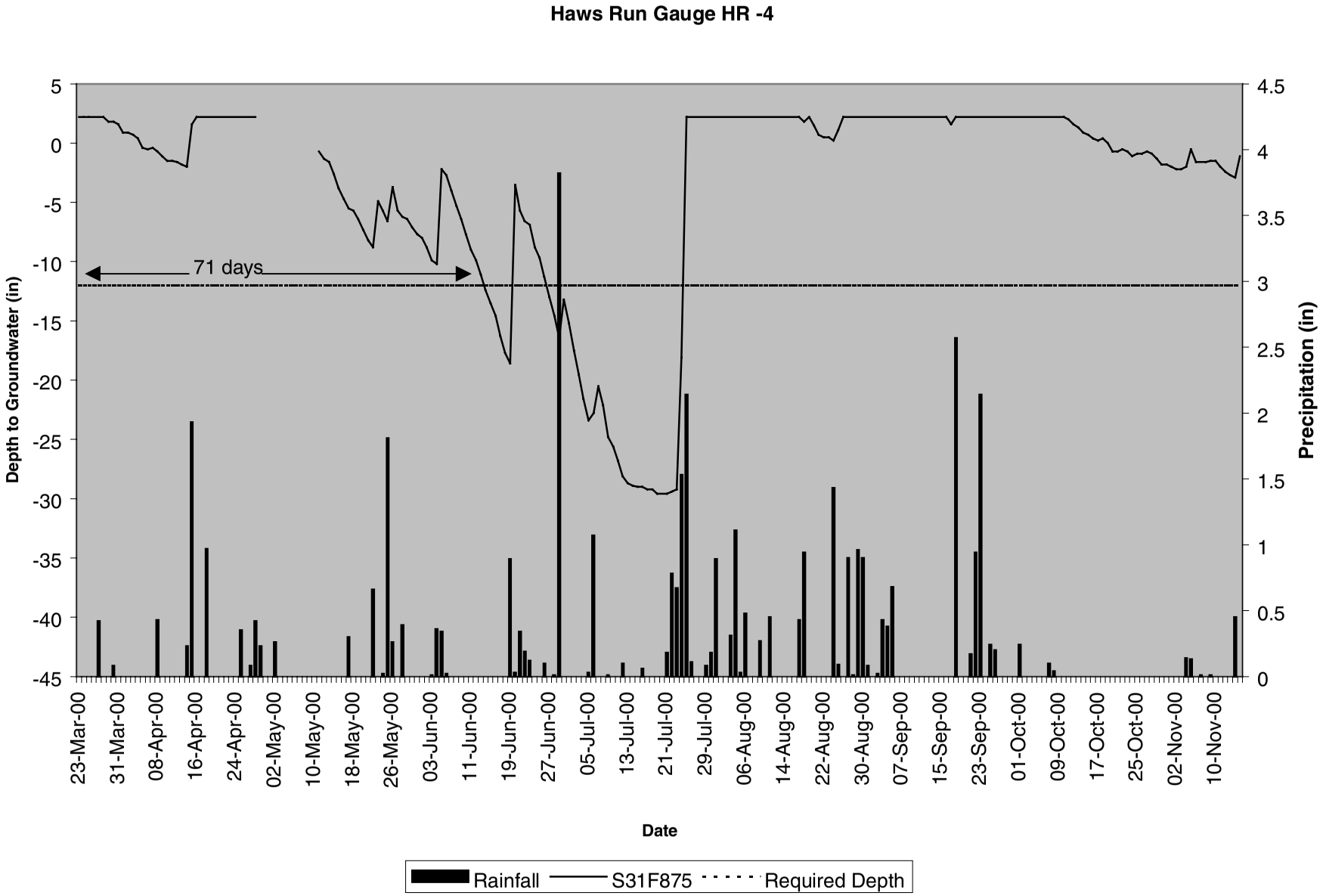
NCDOT will continue to monitor the site for both vegetation and hydrologic success.

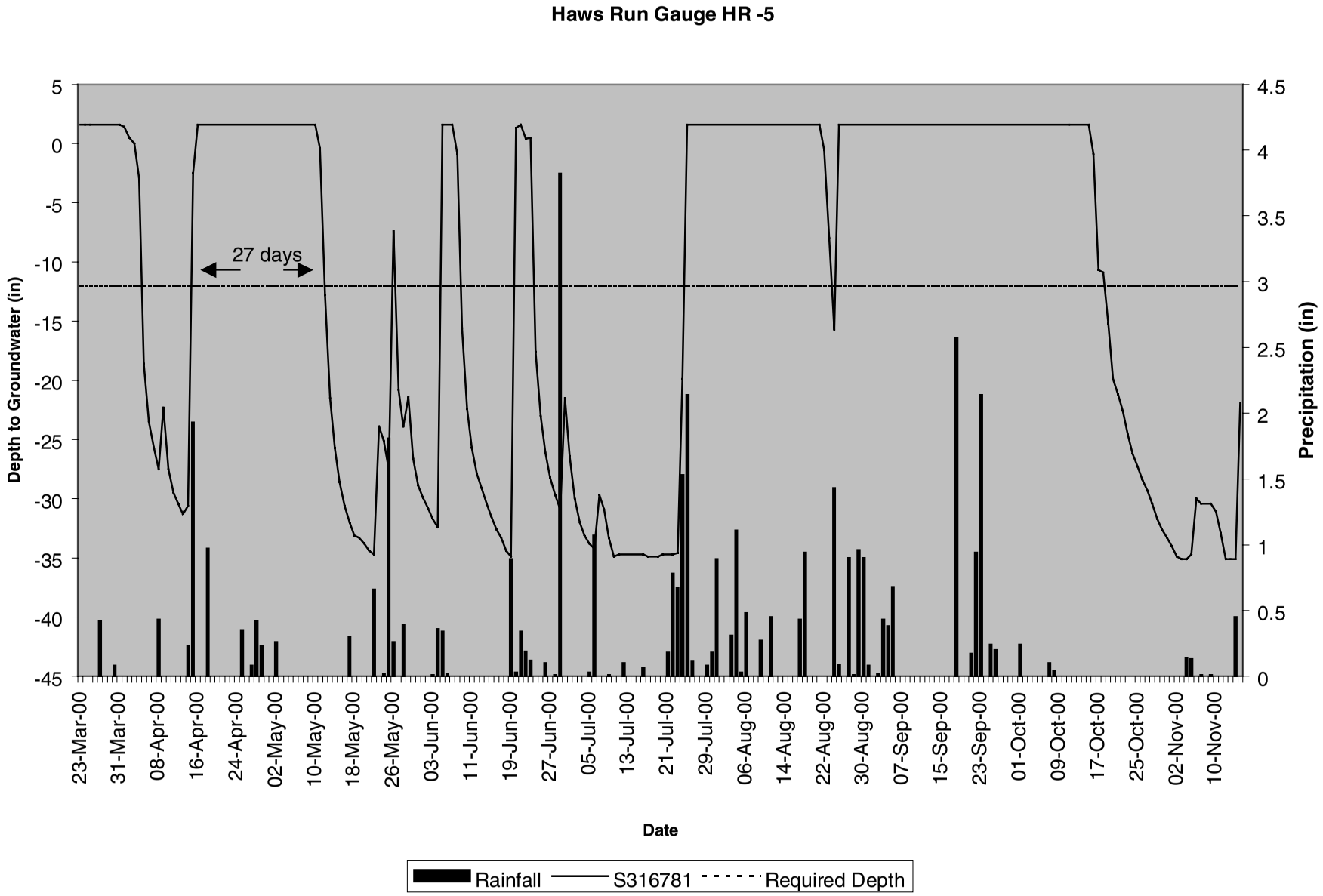
Appendix A
Depth to Groundwater Graphs

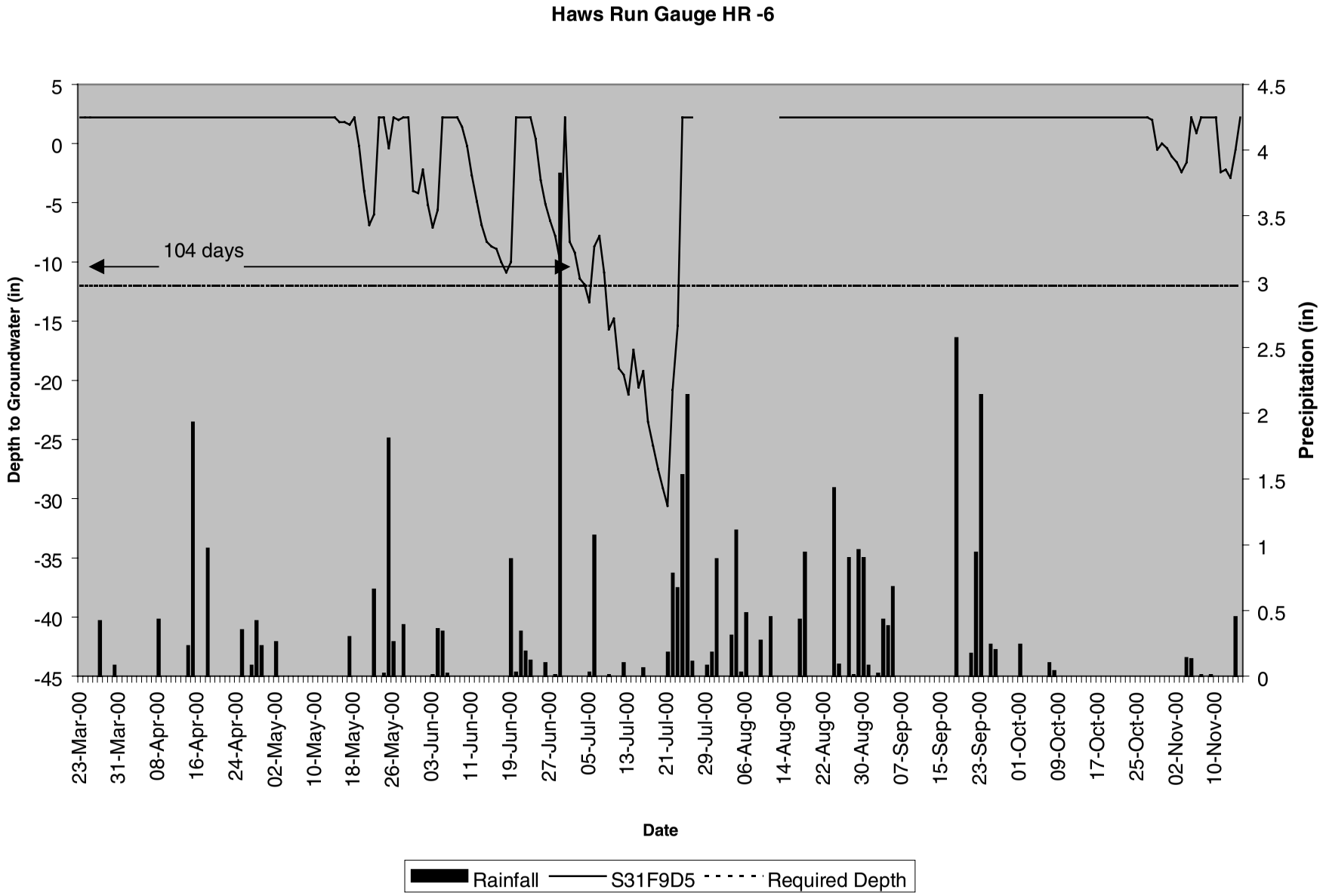

Haws Run Gauge HR -1
Depth to Groundwater (in)
Precipitation (in)
59 days
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00
Date
Rainfall
S31F85F
Required Depth

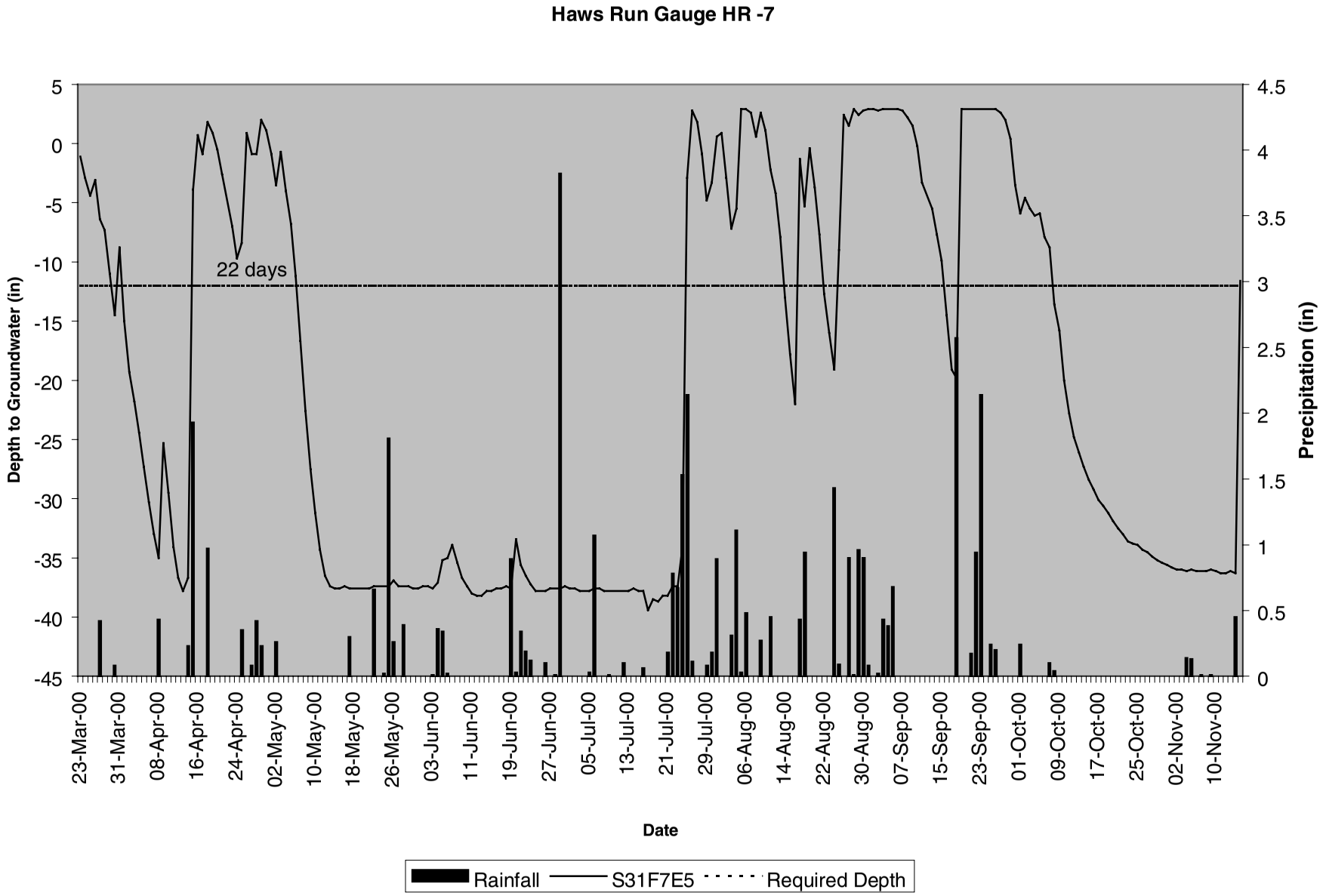

Haws Run Gauge HR -2
74 days
Depth to Groundwater (in)
Precipitation (in)
Date
Rainfall
S31F82D
Required Depth
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00

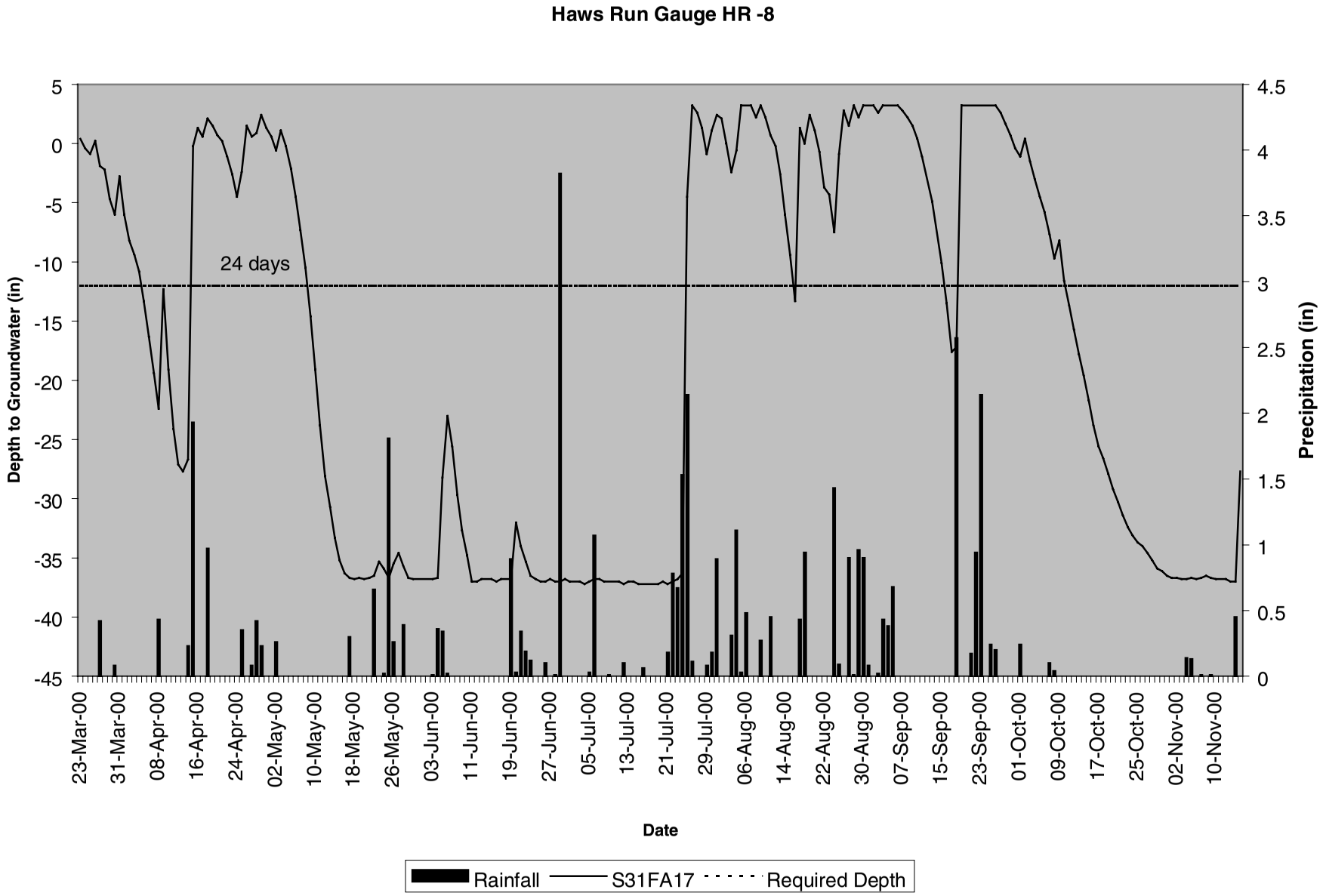

Haws Run Gauge HR -3
Depth to Groundwater (in)
Precipitation (in)
51 days
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00
Date
Rainfall
S31FA50
Required Depth

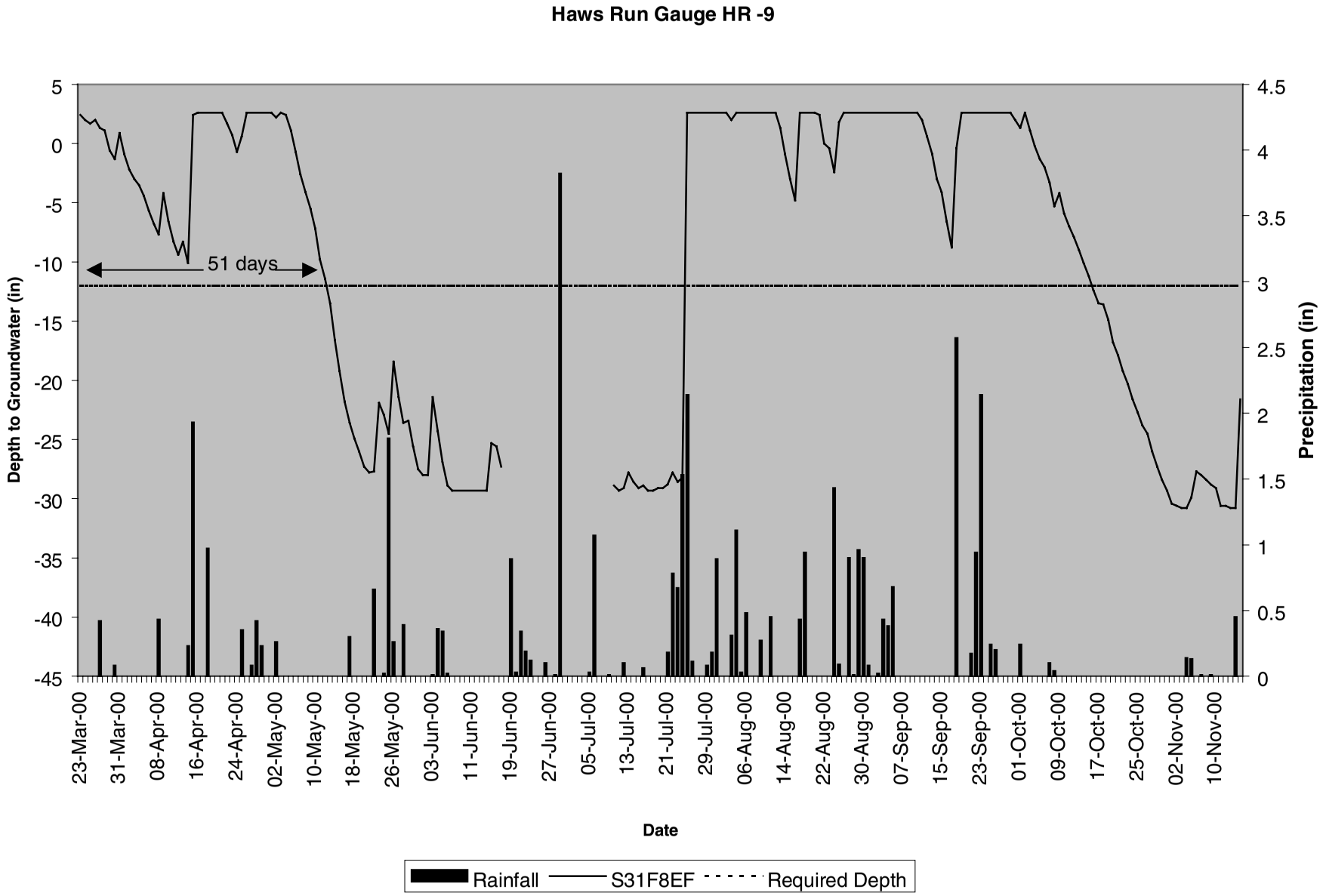

Haws Run Gauge HR -4
Depth to Groundwater (in)
Precipitation (in)
71 days
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00
Date
Rainfall
S31F875
Required Depth

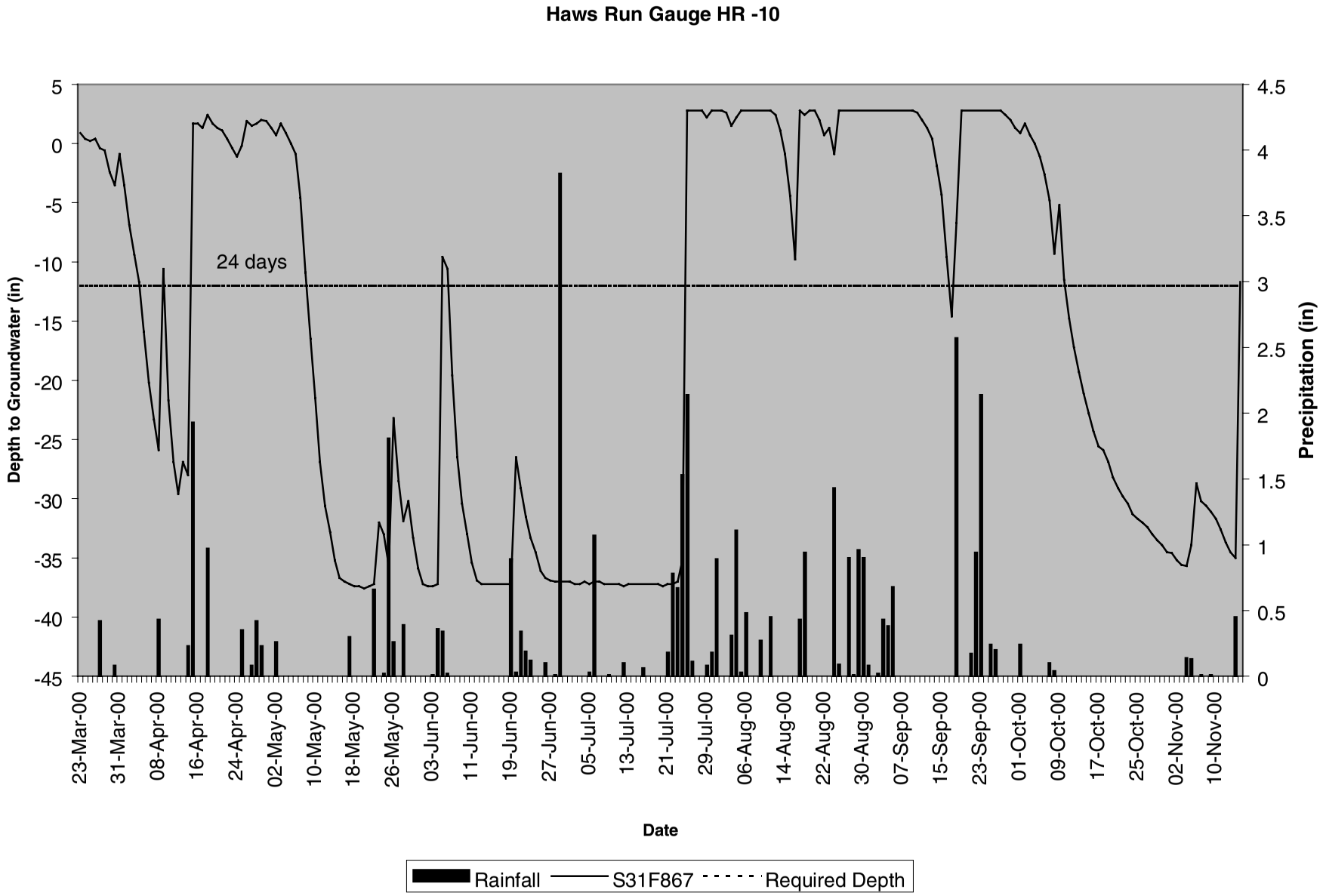

Haws Run Gauge HR -5
Depth to Groundwater (in)
Precipitation (in)
27 days
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00
Date
Rainfall
S316781
Required Depth

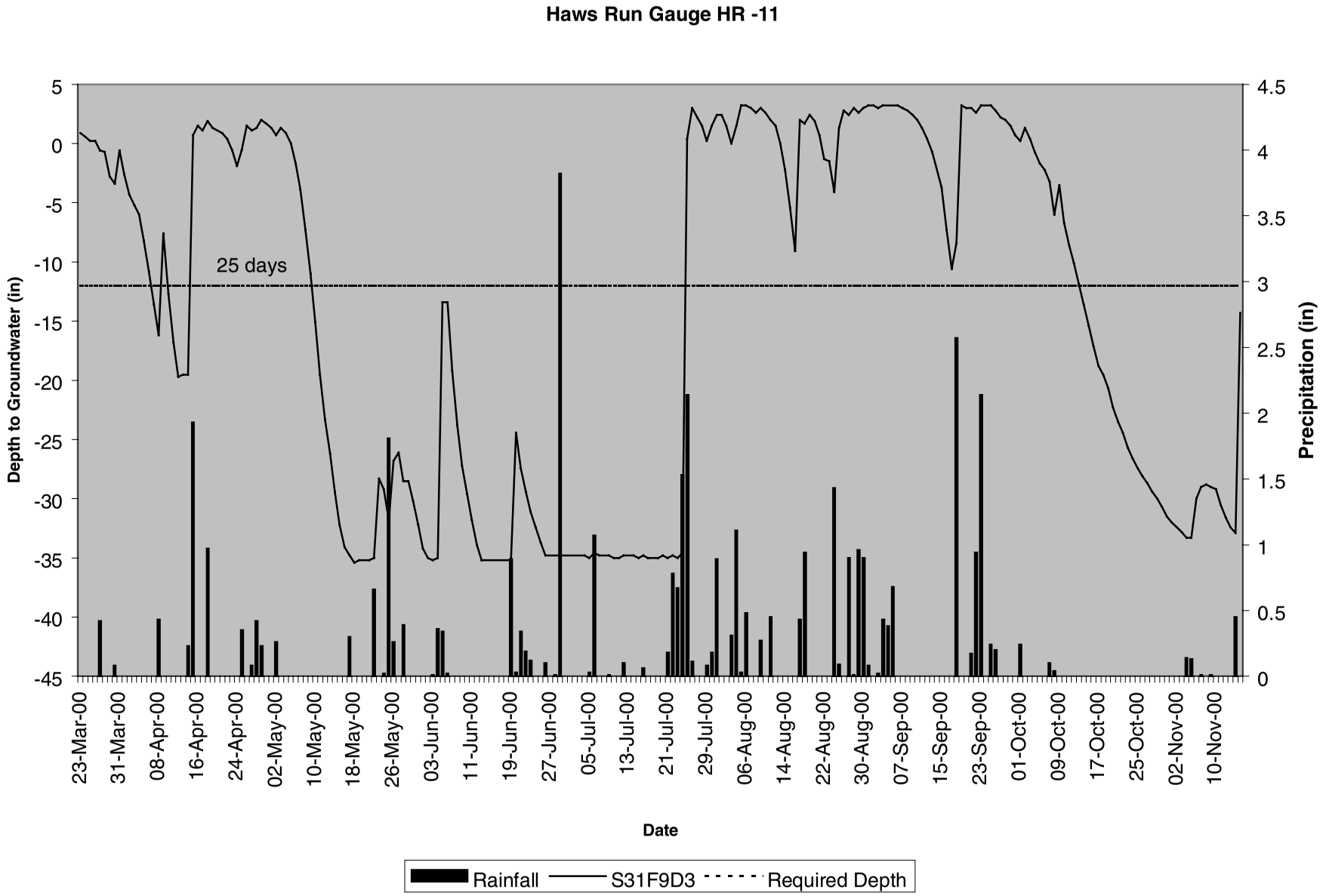

Haws Run Gauge HR -6
104 days
Depth to Groundwater (in)
Precipitation (in)
Date
Rainfall
S31F9D5
Required Depth
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00

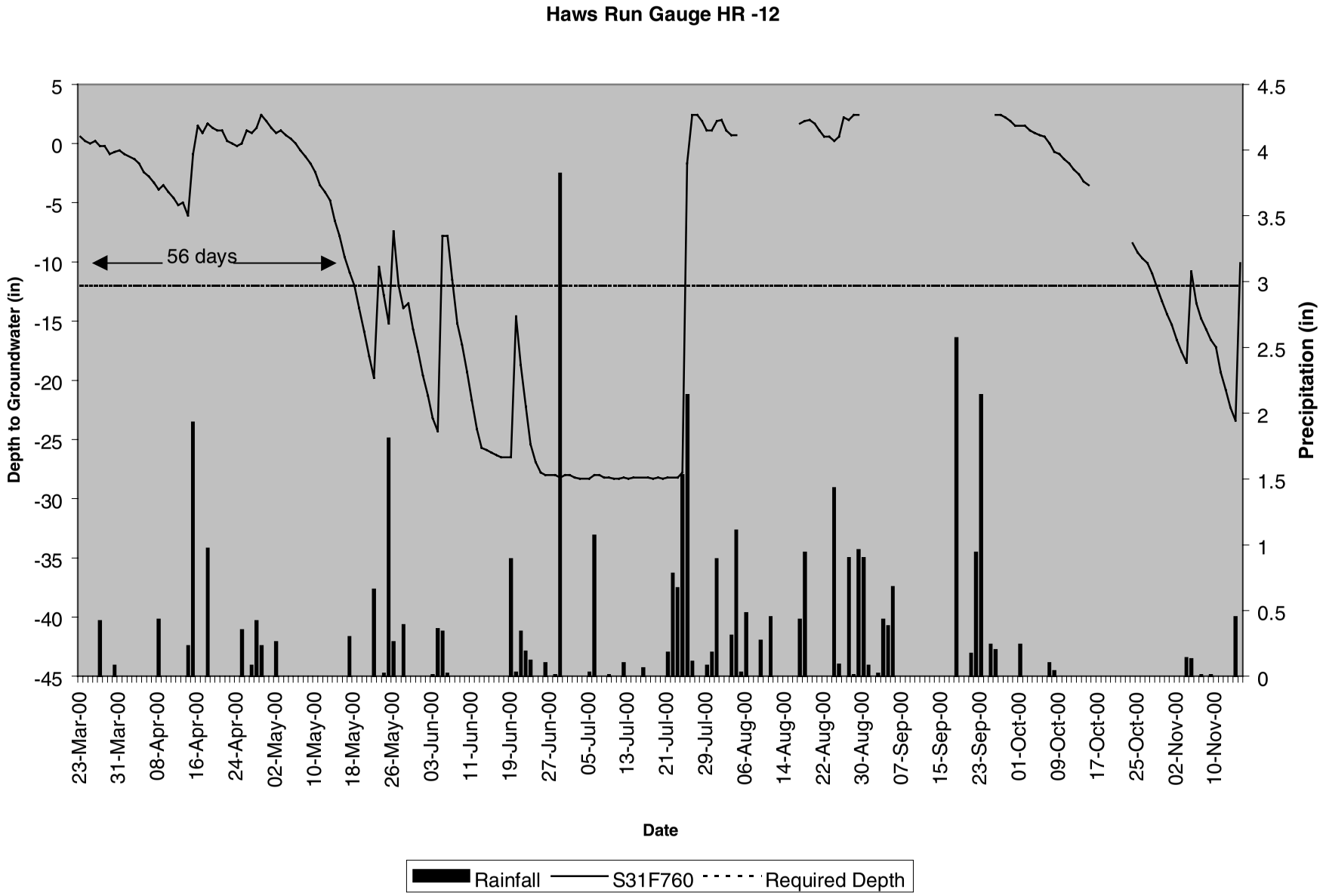

Haws Run Gauge HR -7
Depth to Groundwater (in)
Precipitation (in)
22 days
Date
Rainfall
S31F7E5
Required Depth
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00

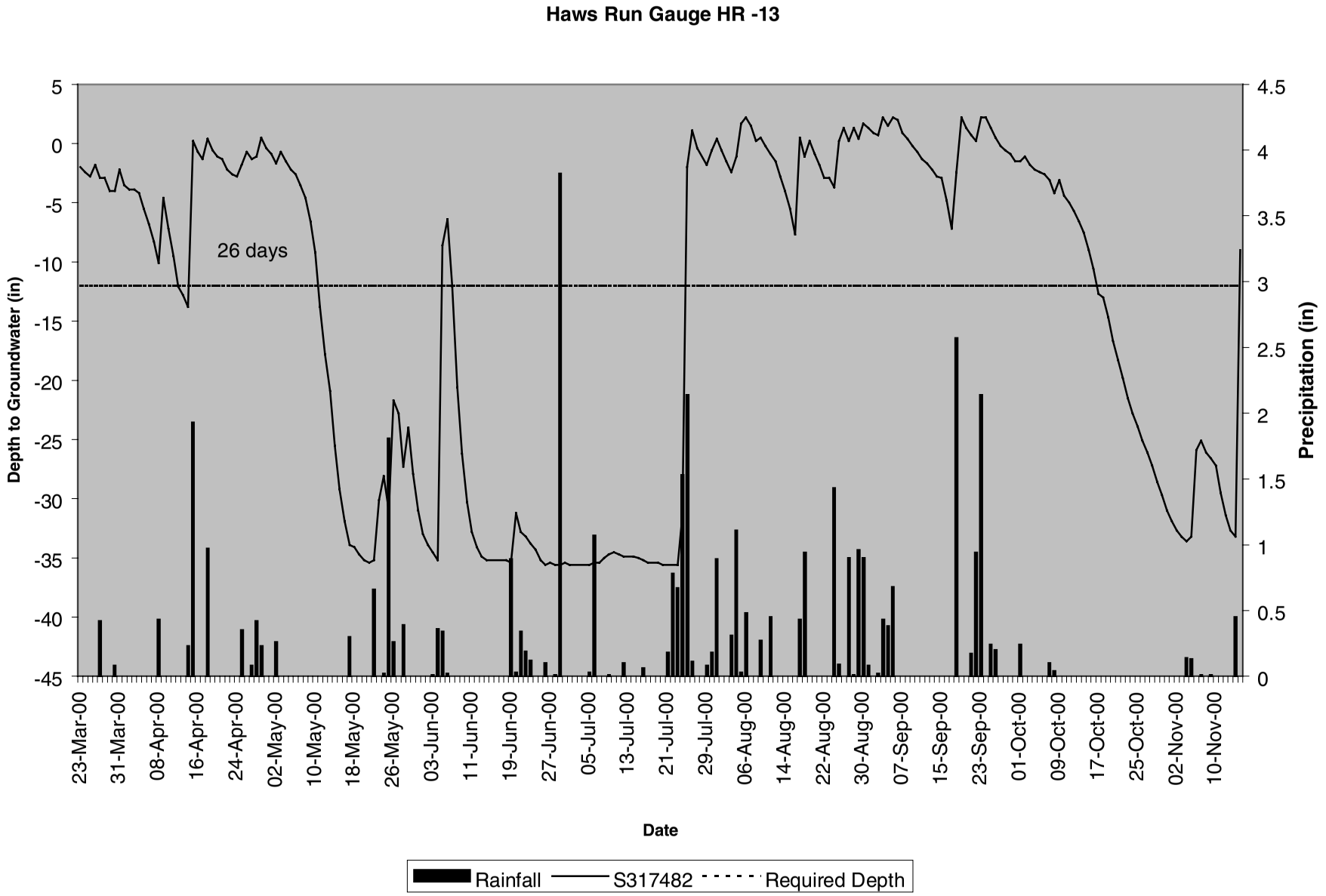

Haws Run Gauge HR -8
Depth to Groundwater (in)
Precipitation (in)
24 days
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00
Date
Rainfall
S31FA17
Required Depth

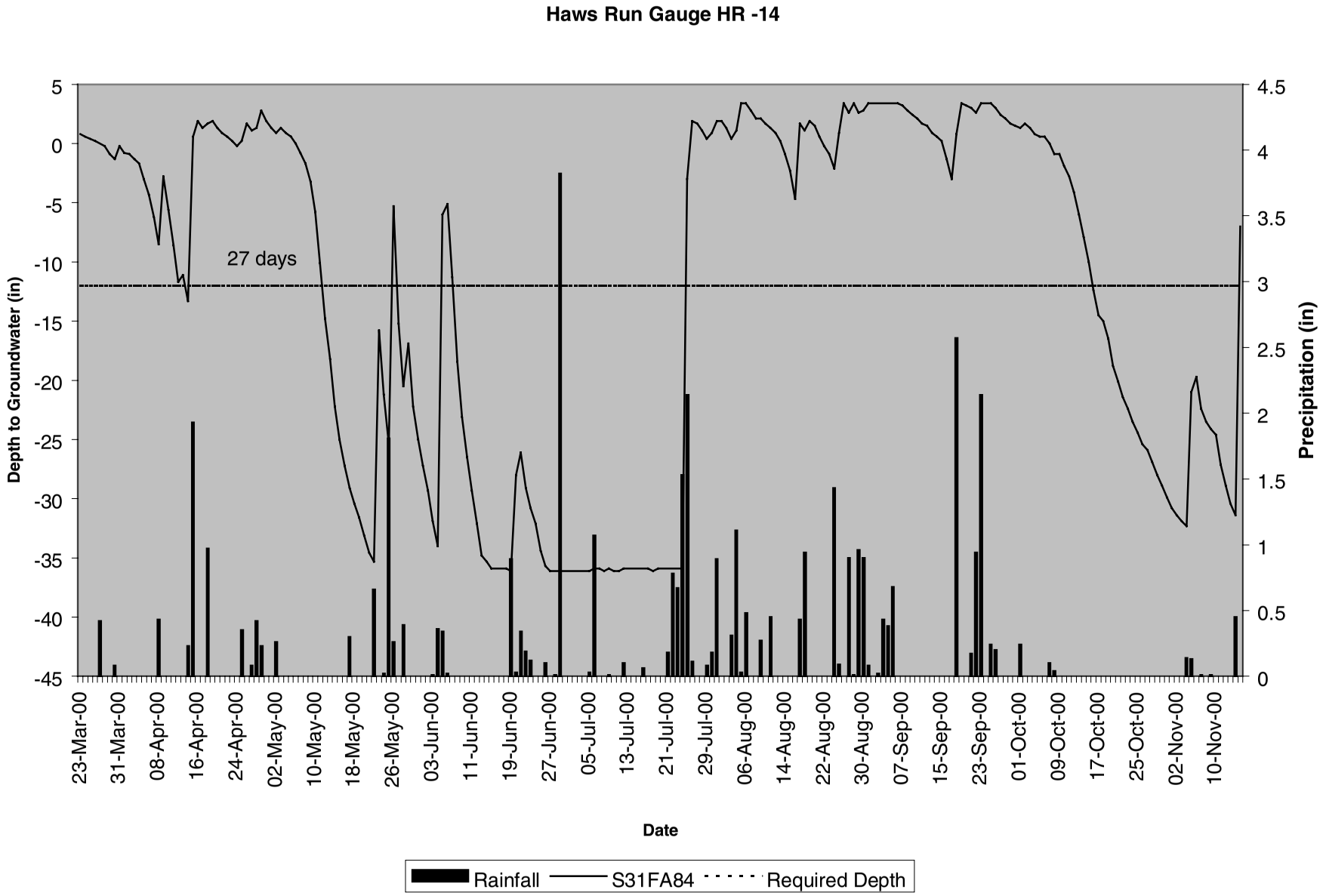

Haws Run Gauge HR -9
Depth to Groundwater (in)
Precipitation (in)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
51 days
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00
Date
Rainfall
S31F8EF
Required Depth

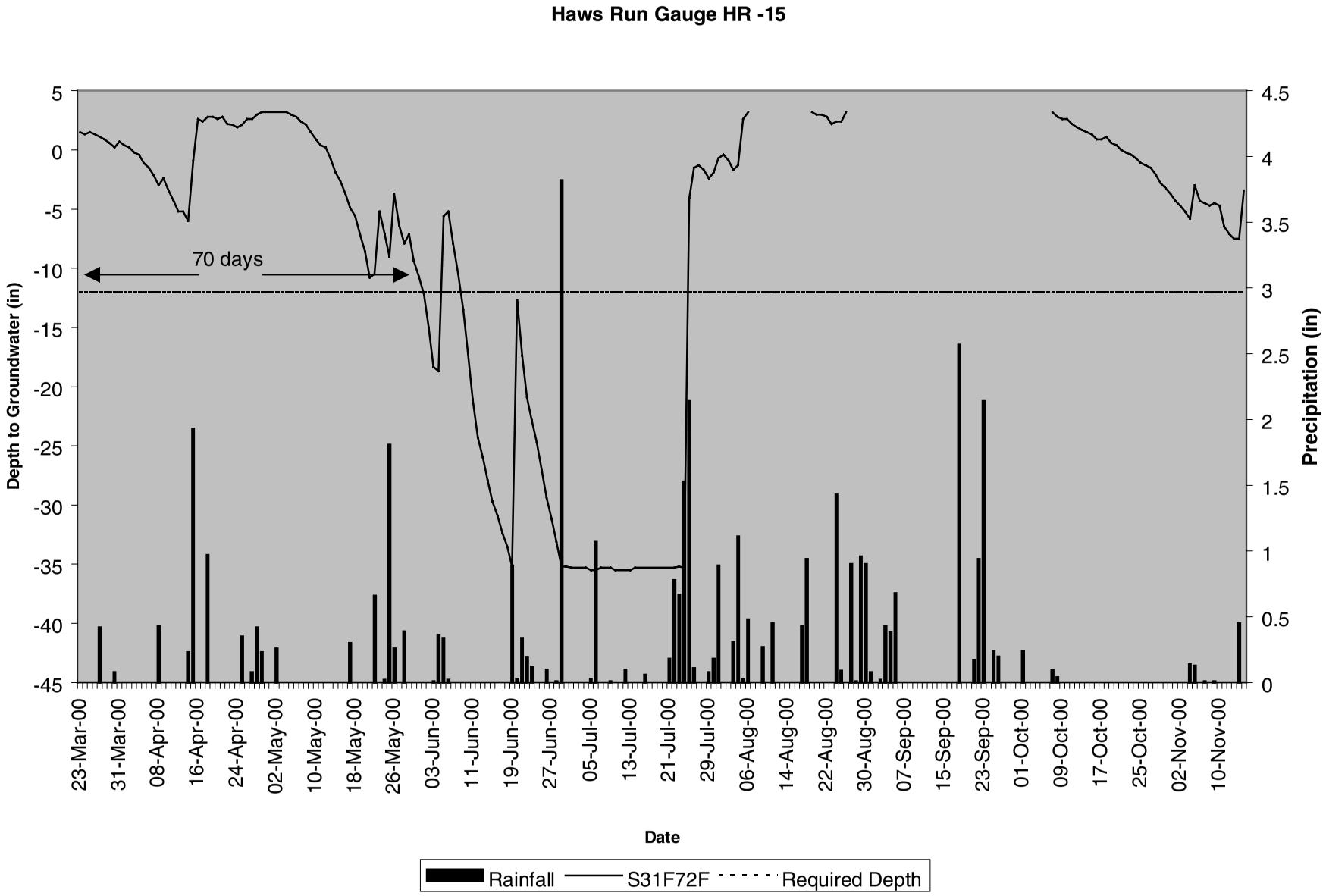

Haws Run Gauge HR -10
24 days
Depth to Groundwater (in)
Precipitation (in)
Date
Rainfall
S31F867
Required Depth
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00

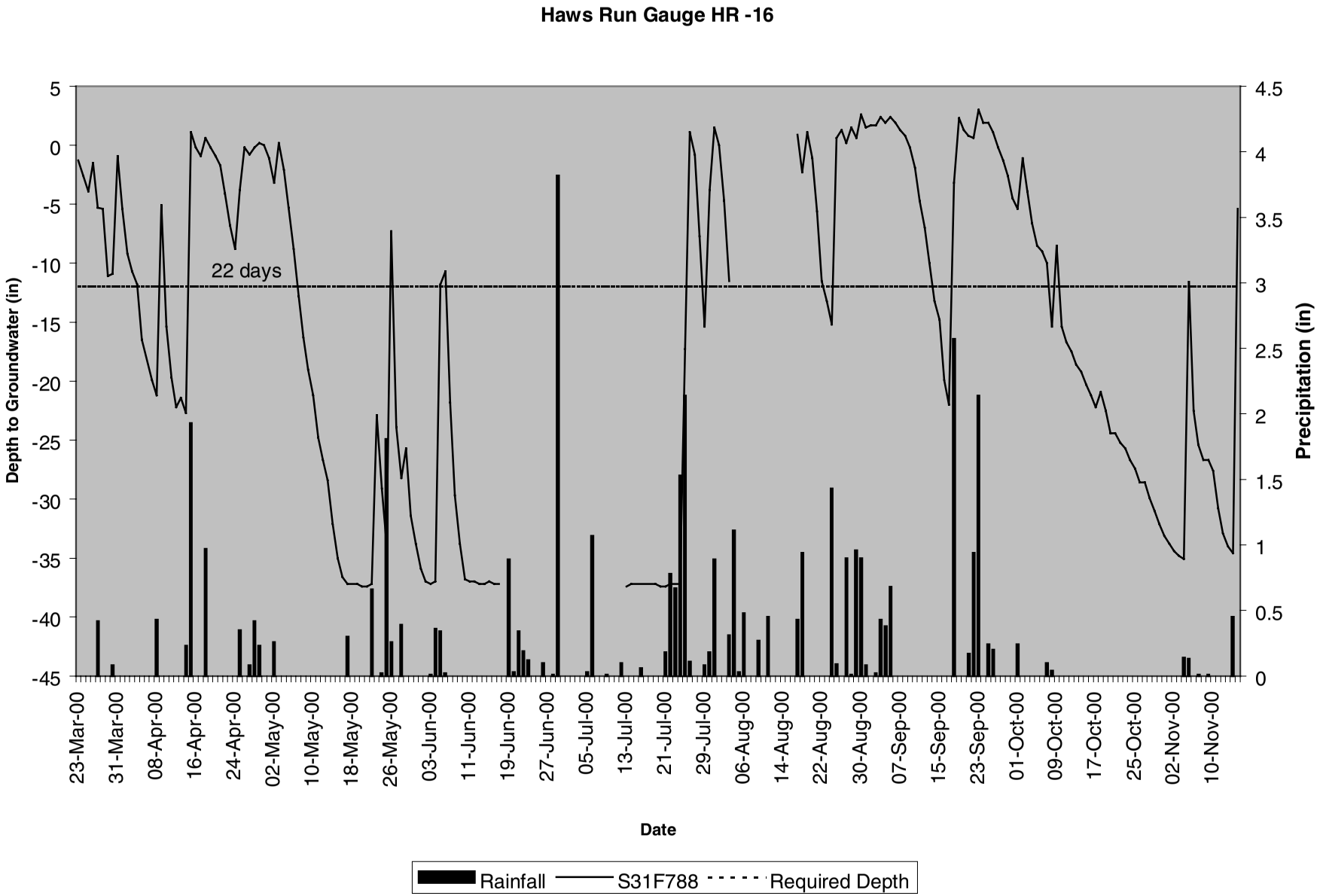

Haws Run Gauge HR -11
25 days
Depth to Groundwater (in)
Precipitation (in)
Date
Rainfall
S31F9D3
Required Depth
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00

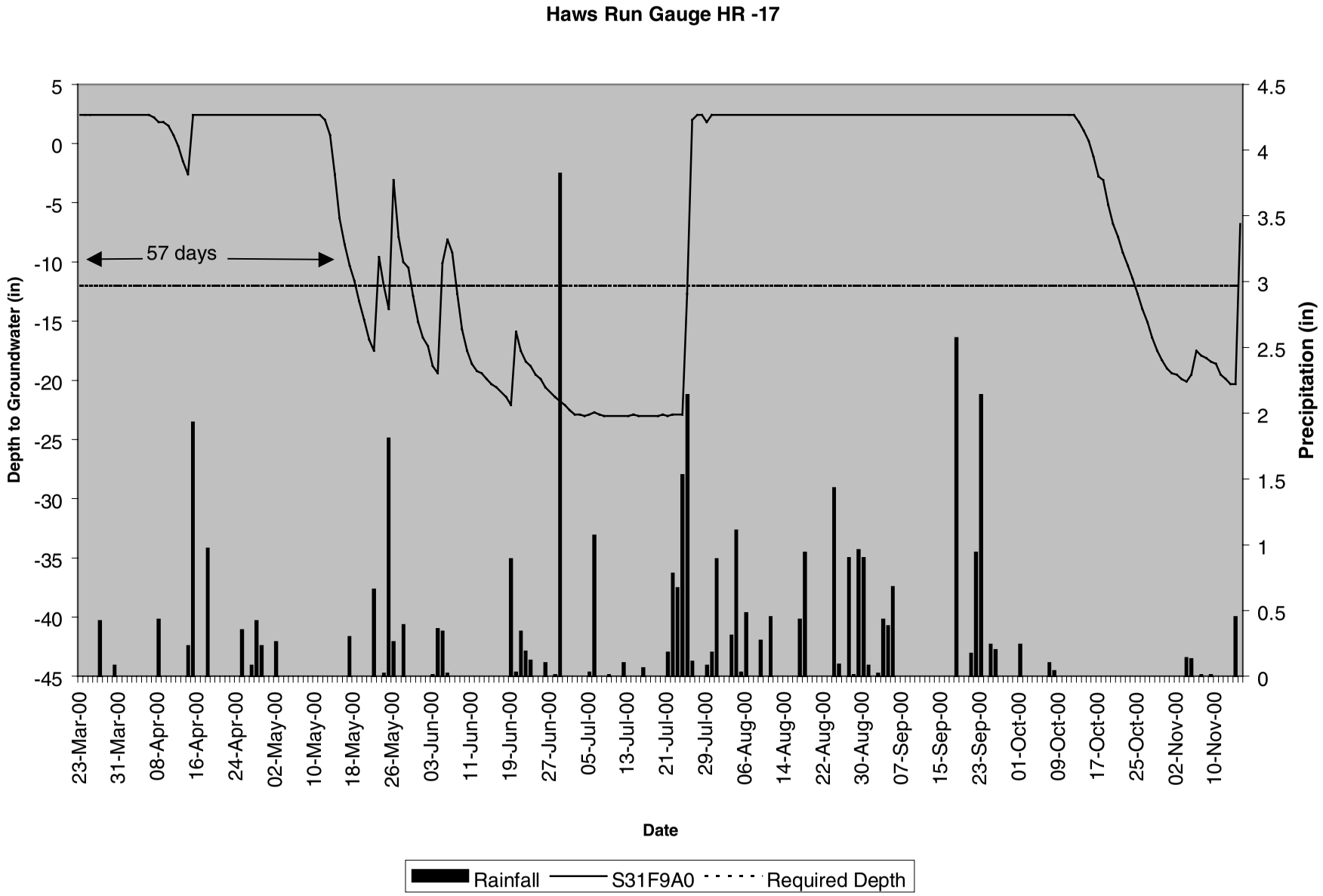

Haws Run Gauge HR -12
Depth to Groundwater (in)
Precipitation (in)
56 days
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00
Date
Rainfall
S31F760
Required Depth

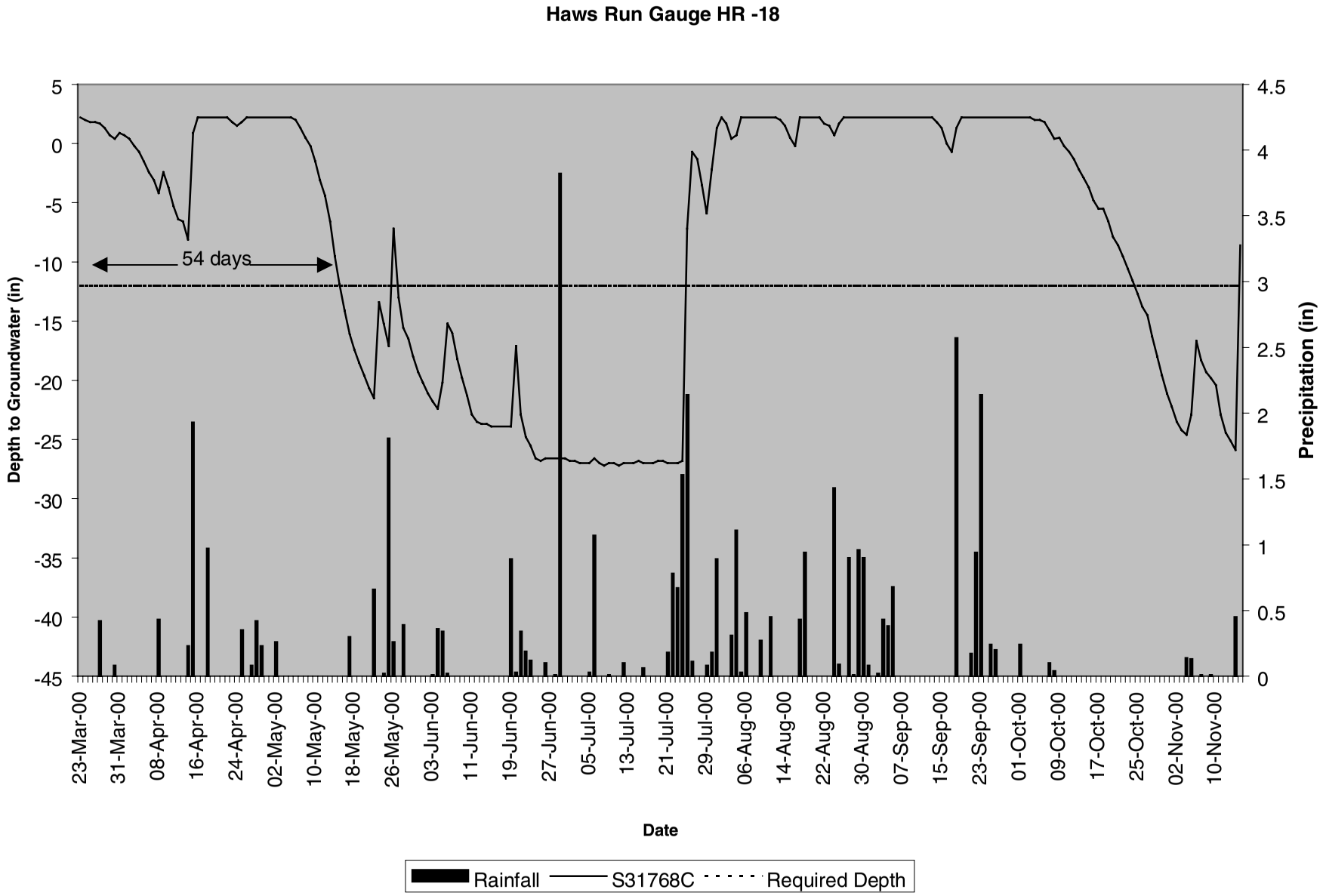

Haws Run Gauge HR -13
26 days
Depth to Groundwater (in)
Precipitation (in)
Date
Rainfall
S317482
Required Depth
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00

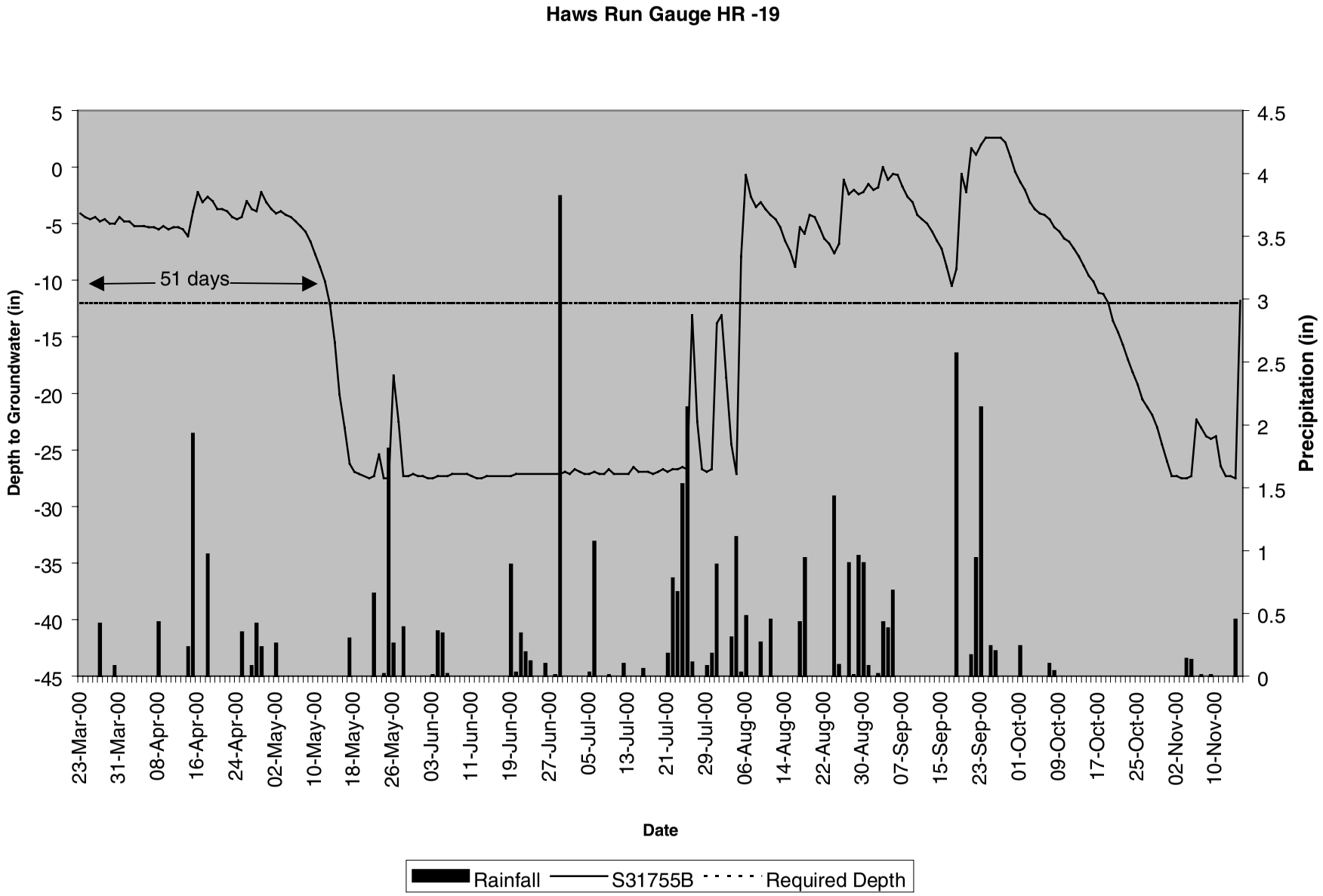

Haws Run Gauge HR -14
27 days
Depth to Groundwater (in)
Precipitation (in)
Date
Rainfall
S31FA84
Required Depth

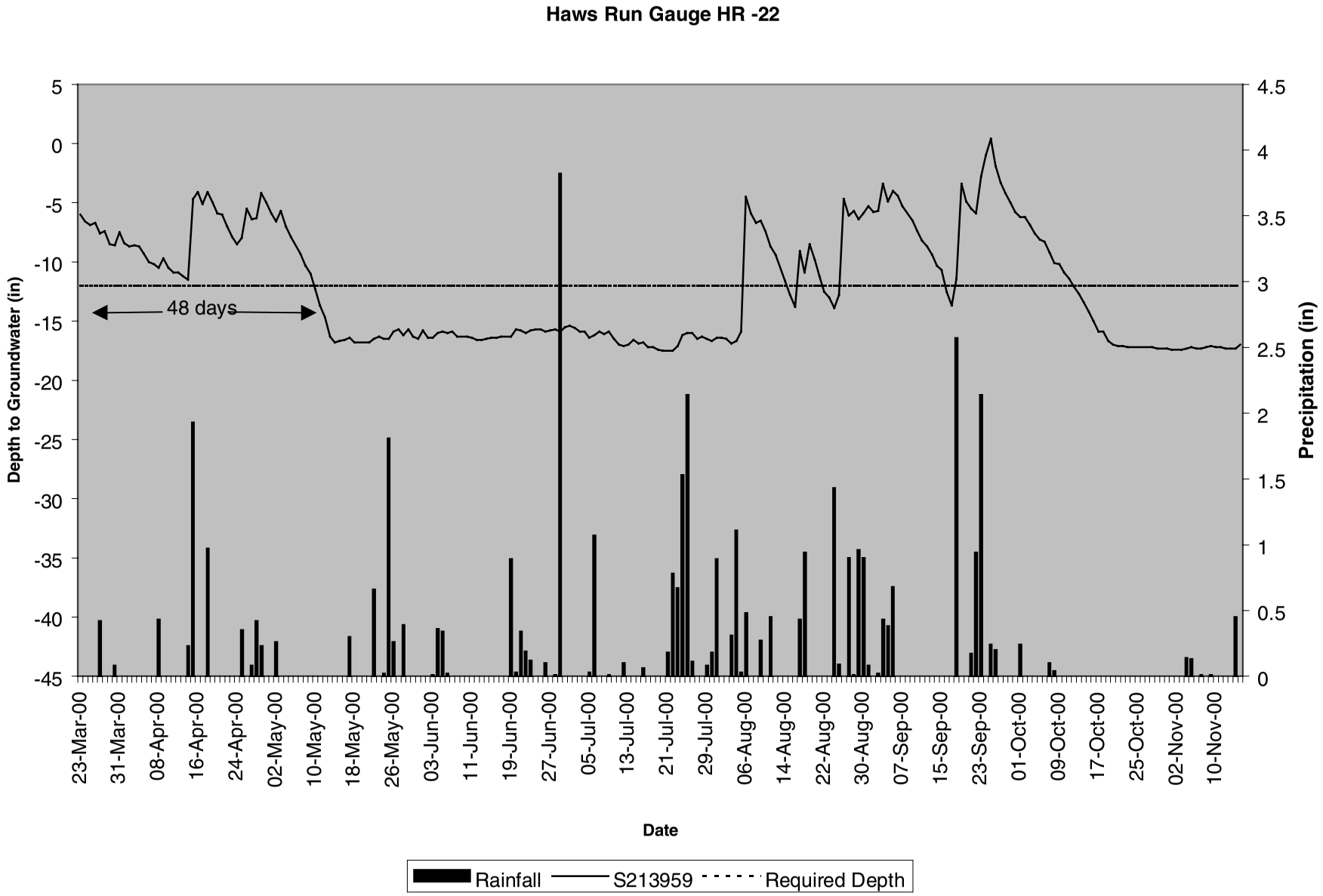

Haws Run Gauge HR -15
70 days
Depth to Groundwater (in)
Precipitation (in)
Date
Rainfall
S31F72F
Required Depth
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00

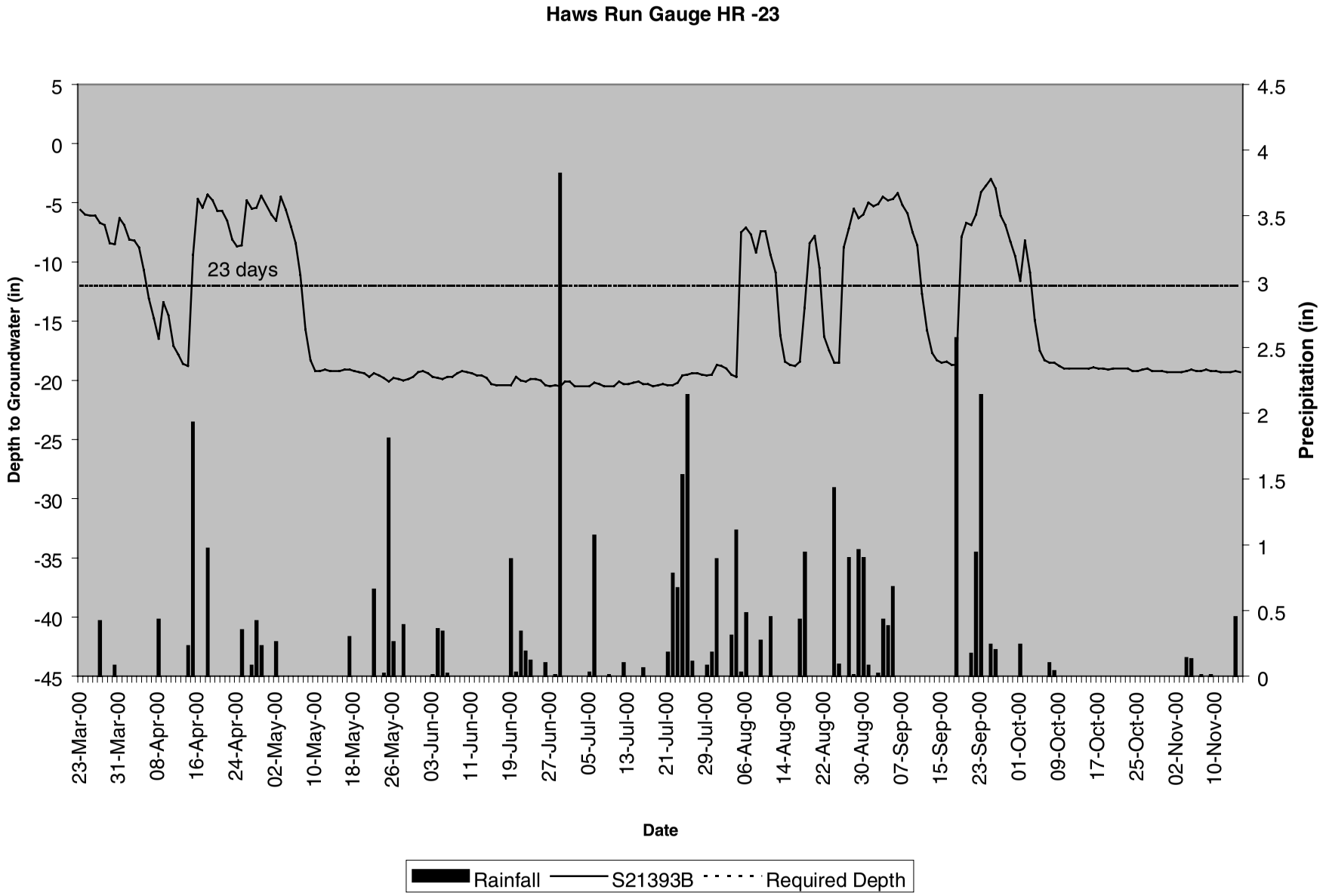

Haws Run Gauge HR -16
22 days
Depth to Groundwater (in)
Precipitation (in)
Date
Rainfall
S31F788
Required Depth
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00

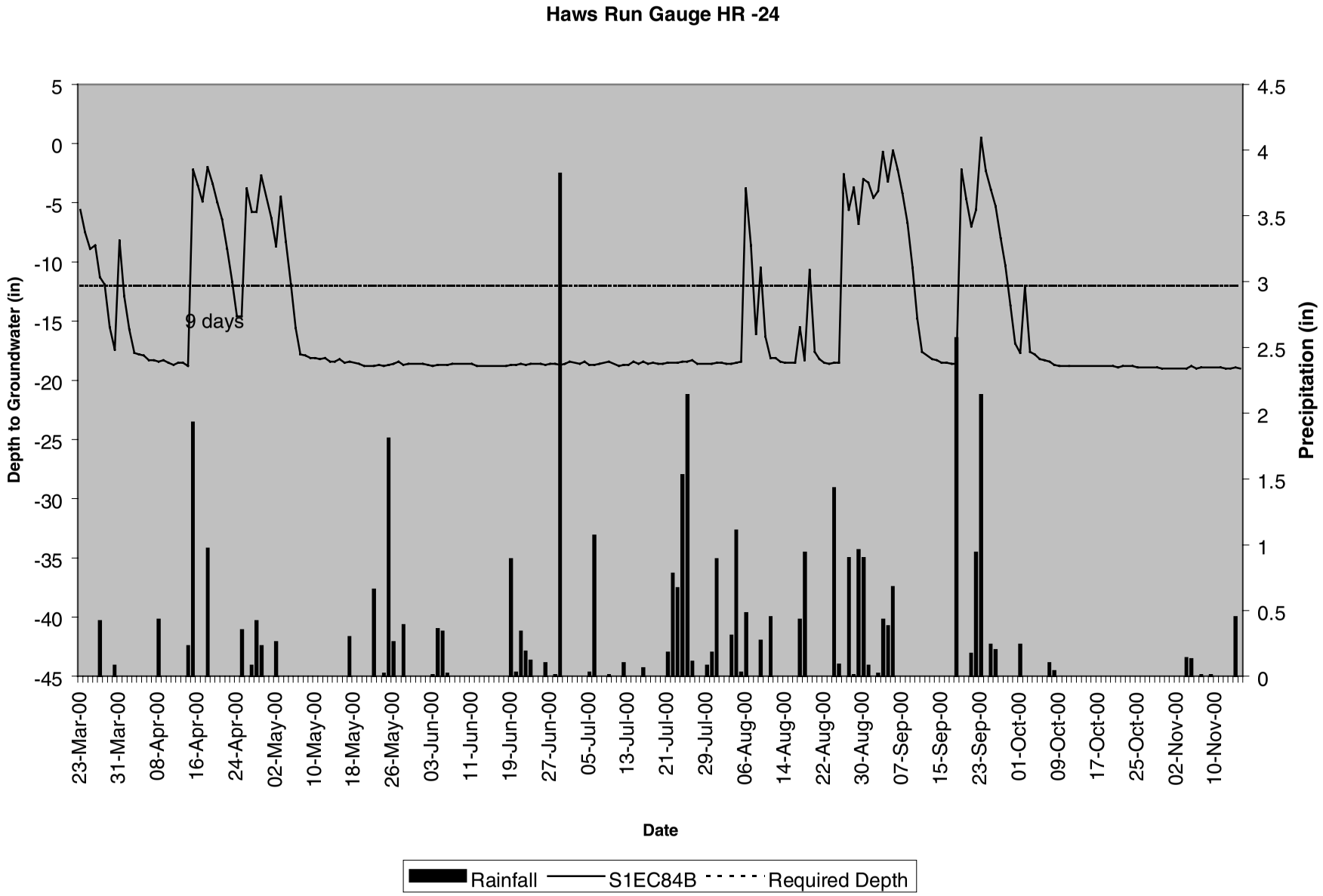

Haws Run Gauge HR -17
57 days
Depth to Groundwater (in)
Precipitation (in)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00
Date
Rainfall
S31F9A0
Required Depth

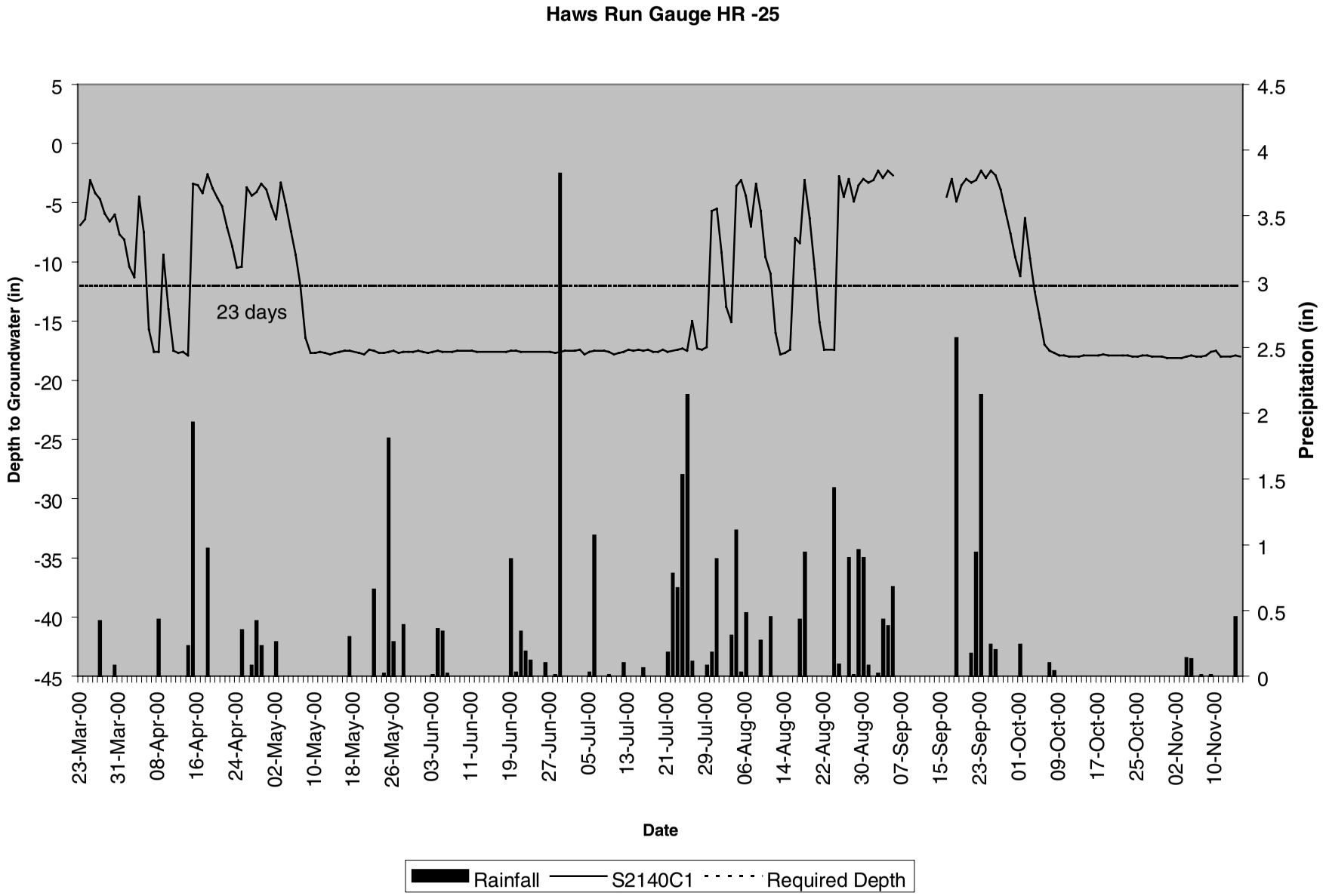

Haws Run Gauge HR -18
Depth to Groundwater (in)
Precipitation (in)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
54 days
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00
Date
Rainfall
S31768C
Required Depth


Haws Run Gauge HR -19
51 days
Depth to Groundwater (in)
Precipitation (in)
Date
Rainfall
S31755B
Required Depth
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00


Haws Run Gauge HR -22
Depth to Groundwater (in)
Precipitation (in)
48 days
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00
Date
Rainfall
S213959
Required Depth

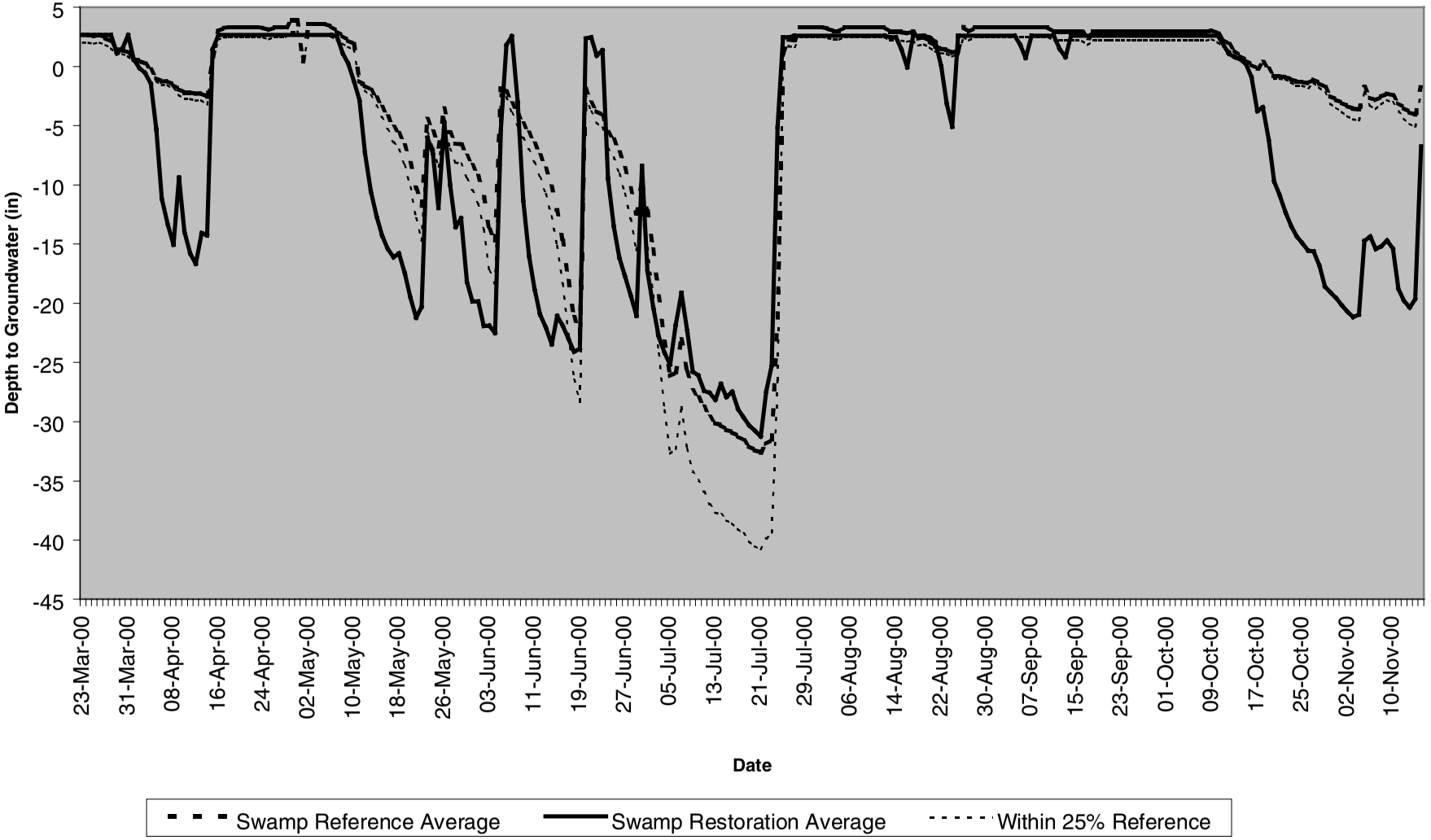

Haws Run Gauge HR -23
23 days
Depth to Groundwater (in)
Precipitation (in)
Date
Rainfall
S21393B
Required Depth
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00


Haws Run Gauge HR -24
Depth to Groundwater (in)
Precipitation (in)
9 days
Date
Rainfall
S1EC84B
Required Depth
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00

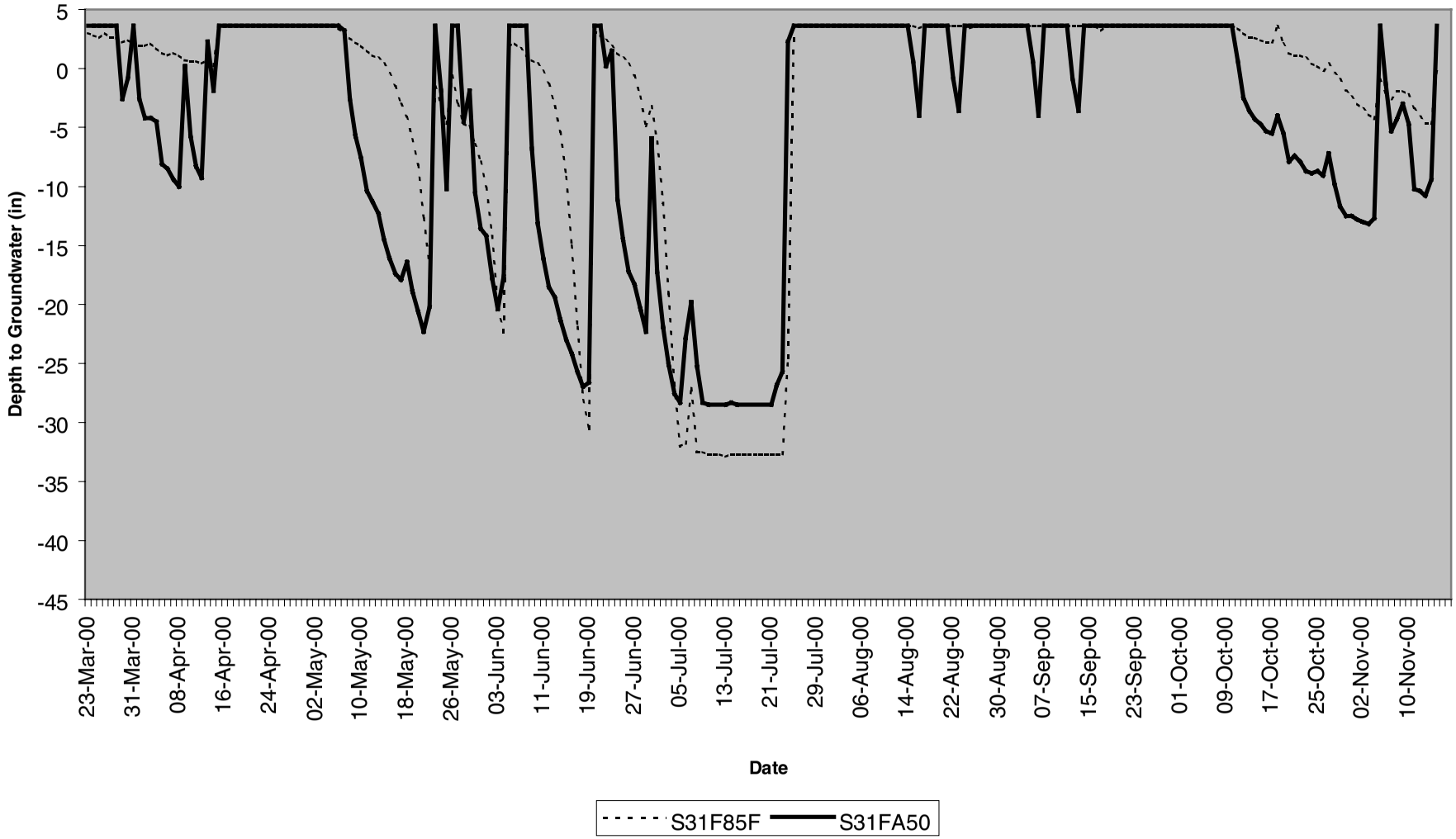

Haws Run Gauge HR -25
Depth to Groundwater (in)
Precipitation (in)
23 days
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00
Date
Rainfall
S2140C1
Required Depth

Appendix B
Comparison of Reference and Restoration Gauges

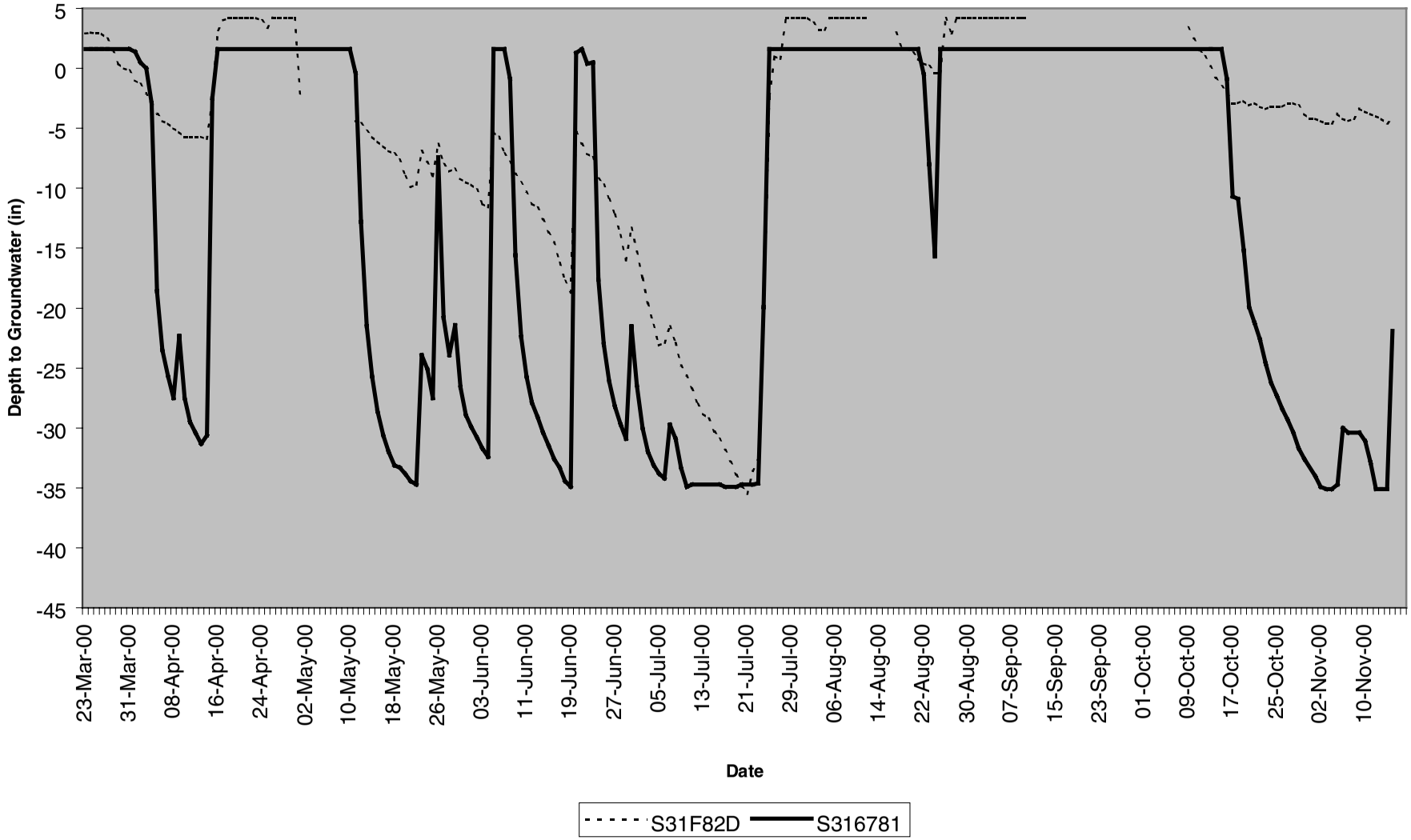
Swamp Forest
Average Reference vs. Average Restoration

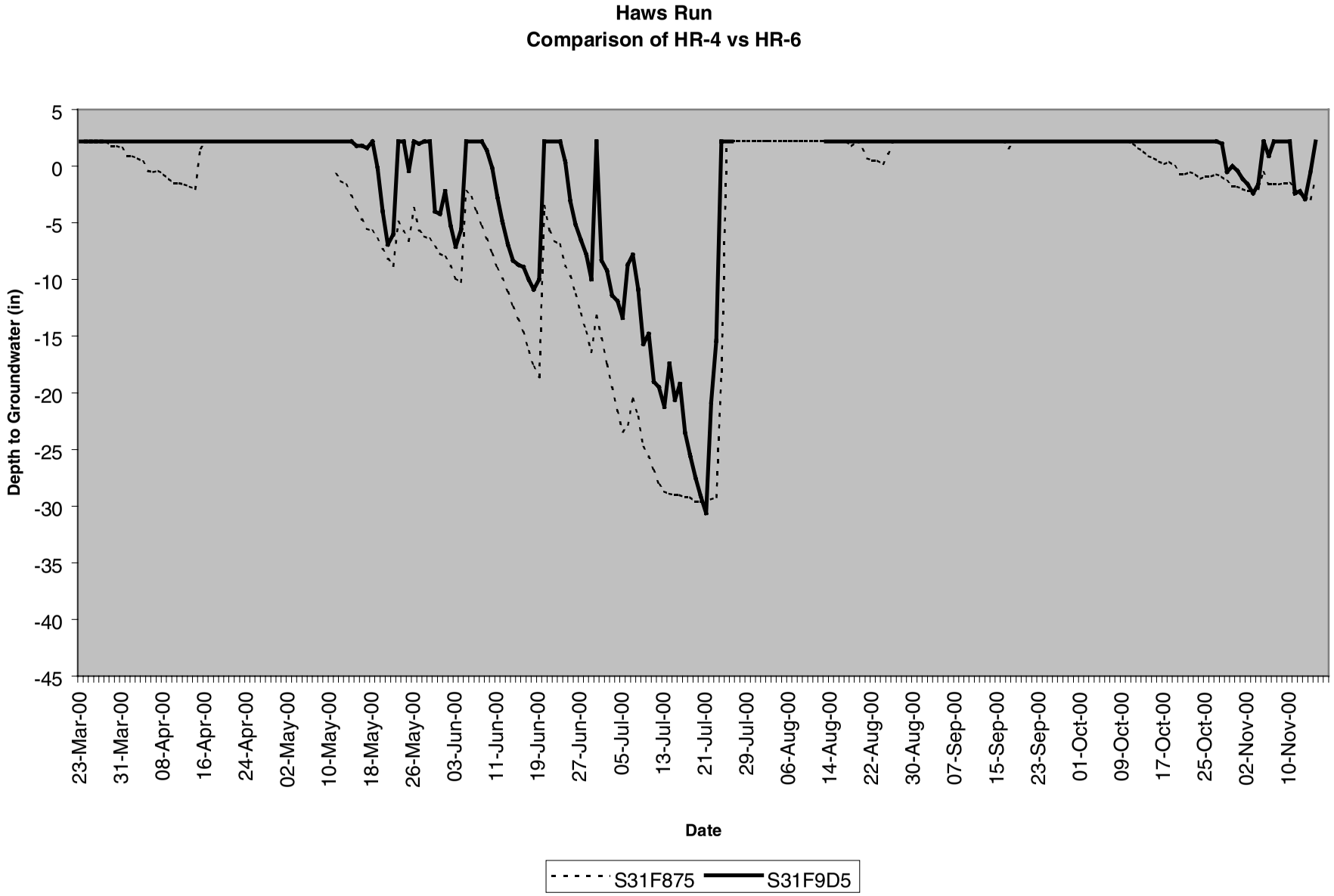


Haws Run
Comparison of HR-1 and HR-3

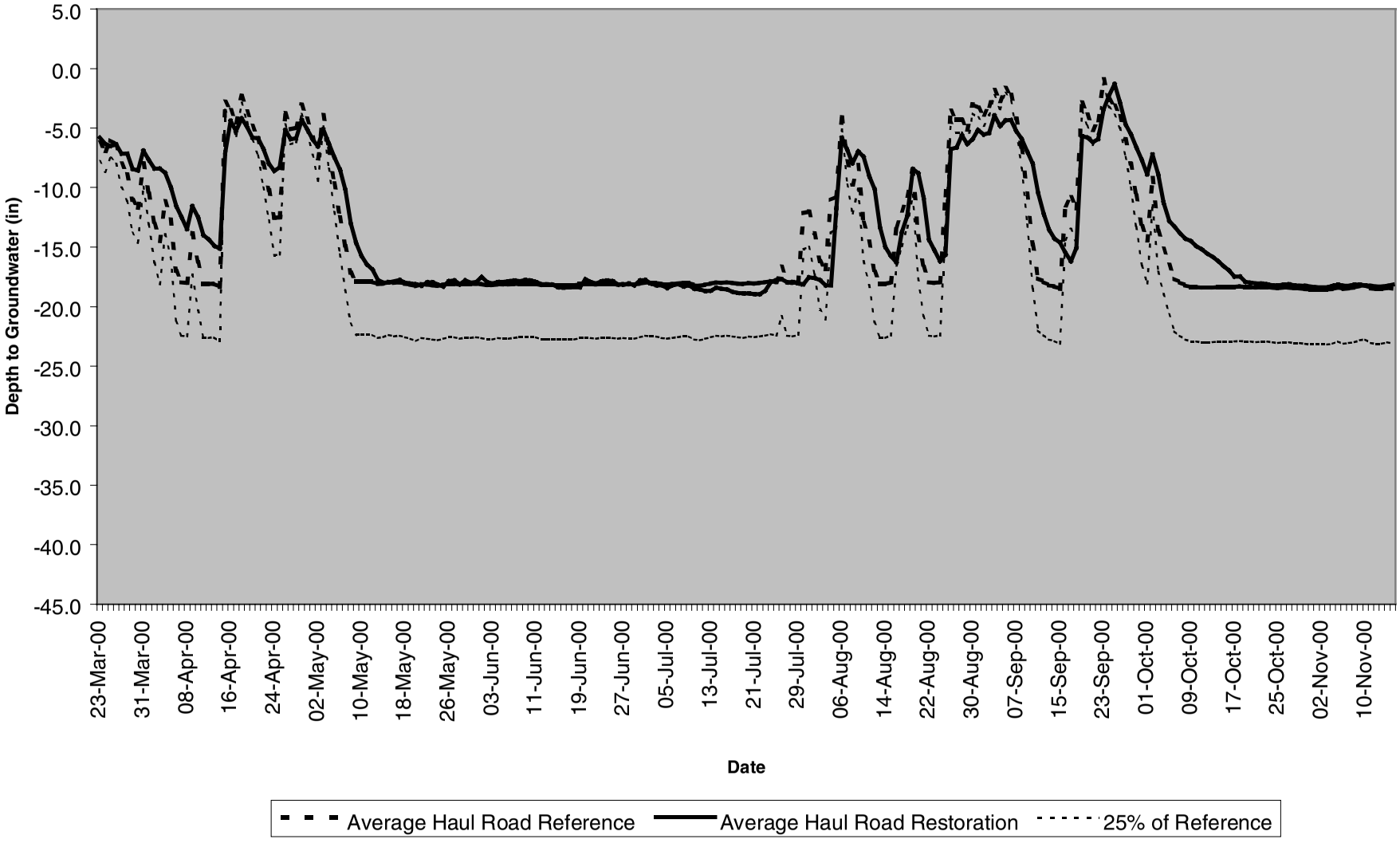


Haws Run
Comparison of HR-2 vs. HR-5




Haws Run
Comparison of HR-4 vs HR-6
Depth to Groundwater (in)
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
23-Mar-00
31-Mar-00
08-Apr-00
16-Apr-00
24-Apr-00
02-May-00
10-May-00
18-May-00
26-May-00
03-Jun-00
11-Jun-00
19-Jun-00
27-Jun-00
05-Jul-00
13-Jul-00
21-Jul-00
29-Jul-00
06-Aug-00
14-Aug-00
22-Aug-00
30-Aug-00
07-Sep-00
15-Sep-00
23-Sep-00
01-Oct-00
09-Oct-00
17-Oct-00
25-Oct-00
02-Nov-00
10-Nov-00
Date
S31F875
S31F9D5

Haws Run Haul Road
Average Reference vs. Average Restoration



Appendix C Site Photos

Photo 1

Photo 2

Photo 3

Photo 4

Photo 5

Photo 6

Photo 7

Photo 8

Photo 9

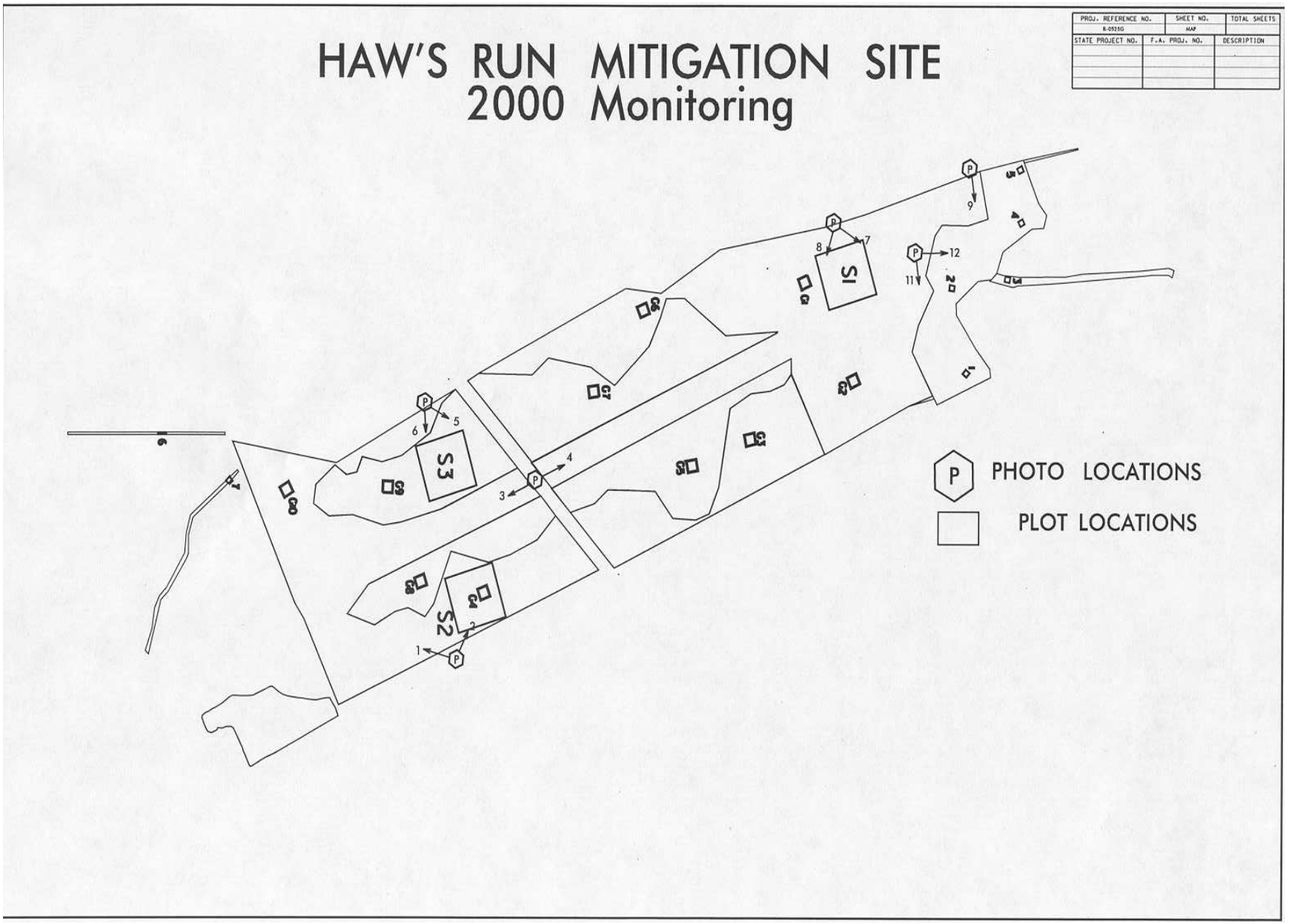
Photo 10 (Rock flume)

Photo 11

Photo 12

Photo 13

Photo 14


HAW'S RUN MITIGATION SITE
2000 Monitoring
PROJ. REFERENCE NO.
R-2525G
SHEET NO.
MAP
TOTAL SHEETS
STATE PROJECT NO.
F.A. PROJ. NO.
DESCRIPTION
S1
S2
S3
PHOTO LOCATIONS
PLOT LOCATIONS

Appendix D

Slope Repair Plan

Haws Run
Pender and Onslow Counties
Tip Project R-2405WM

State Project Number 6.259002T

June 8, 2000

Project Description

The Haws Run Mitigation site was purchased in 1995 by the NCDOT to provide compensatory mitigation for unavoidable impacts to wetlands resulting from highway construction in the region. Haws Run provides the following types of mitigation:

Bottomland HW	30 ac restoration, 25 ac enhancement, 171 ac preservation
Pine Savanna	81 ac restoration, 99 ac enhancement, 11 ac preservation
Mesic Savanna	113 ac enhancement

Northern Slope Erosion

Several washouts have occurred along the northern side of the site adjacent to the swamp forest area. Rapid rising of the water table underneath the pine savanna during Hurricane Floyd rainfall had resulted in slope failures where the water table surfaces near the swamp. These failures experienced further headwall erosion to the point where they acted as foci for surface water runoff, also drastically increased during the hurricane. These washouts resulted in the deposition of some sediment into the swamp forest area.

Proposed Slope Repair

NCDOT recommends grading the slope to 4:1 and backfilling the washouts. This reduced slope will minimize the potential for failure during rapid rises in the savanna area water table and erosion by surface water runoff. NCDOT recommends installing stone lined drainage channels for surface water drainage from savanna to swamp forest. NCDOT also recommends providing a low berm at top of slope along northern perimeter to direct water toward drainage channels. This should eliminate the potential of surface erosion on the slope face between the savanna and the swamp forest.

Sediment Deposition in Swamp Forest

At the toe of the slope where erosion has deposited sediment into the swamp forest, NCDOT proposes to leave this material undisturbed for the following reasons:

1. The sediment layer represents a minor change in swamp forest topography as one would find in nature.
2. The sediment layer has not adversely impacted the planted trees.
3. The NCDOT feels it would do more harm than good by moving equipment in (and out) to try and pull this small amount of material out of swamp forest.

Proposed Schedule

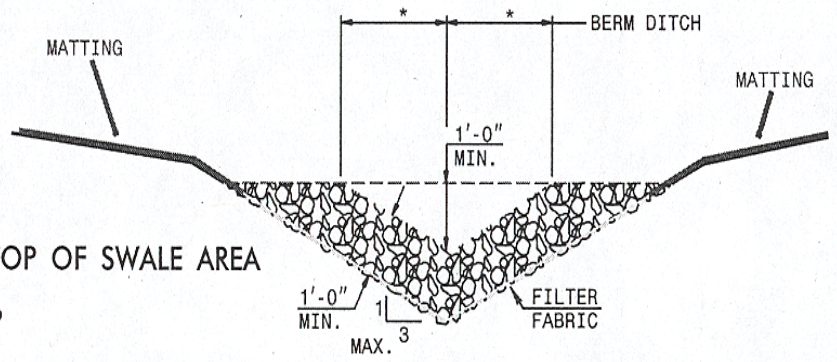
Early June –	Resource agency approval to proceed
July 1 –	Bid Package to Division
September 1 –	Repair of slope to begin
November 1 -	Repair completed

PROJ. REFERENCE NO.	SHEET NO.	TOTAL SHEETS
E-2405W	SLOPE 1	
STATE PROJECT NO.	F.A. PROJ. NO.	DESCRIPTION

HAW'S RUN MITIGATION SITE

ROCK FLUME DETAIL

* DIMENSION TO BE ADJUSTED BY ENGINEER



GENERAL NOTES:

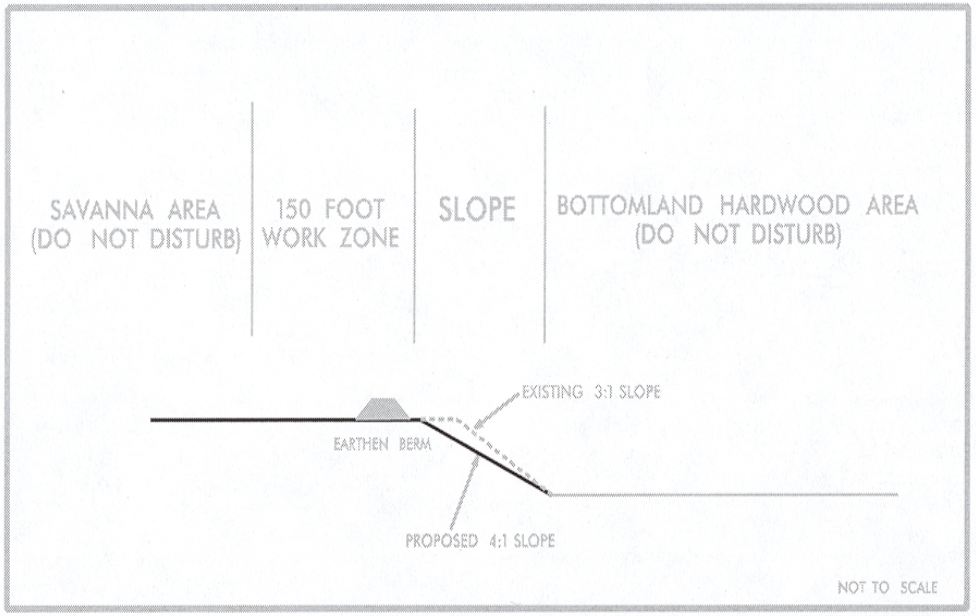
–RIP RAP SHALL BE CLASS `B'.

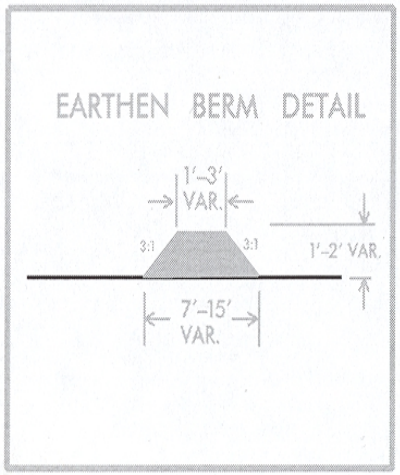
–USE MATTING FROM TOP OF RIP RAP TO TOP OF SWALE AREA

–USE FILTER FABRIC UNDER CLASS `B' RIP RAP

PROJ. REFERENCE NO.	SHEET NO.	TOTAL SHEETS
R-2405WM	SLOPE 2	
STATE PROJECT NO.	F.A. PROJ. NO.	DESCRIPTION

HAW'S RUN MITIGATION SITE





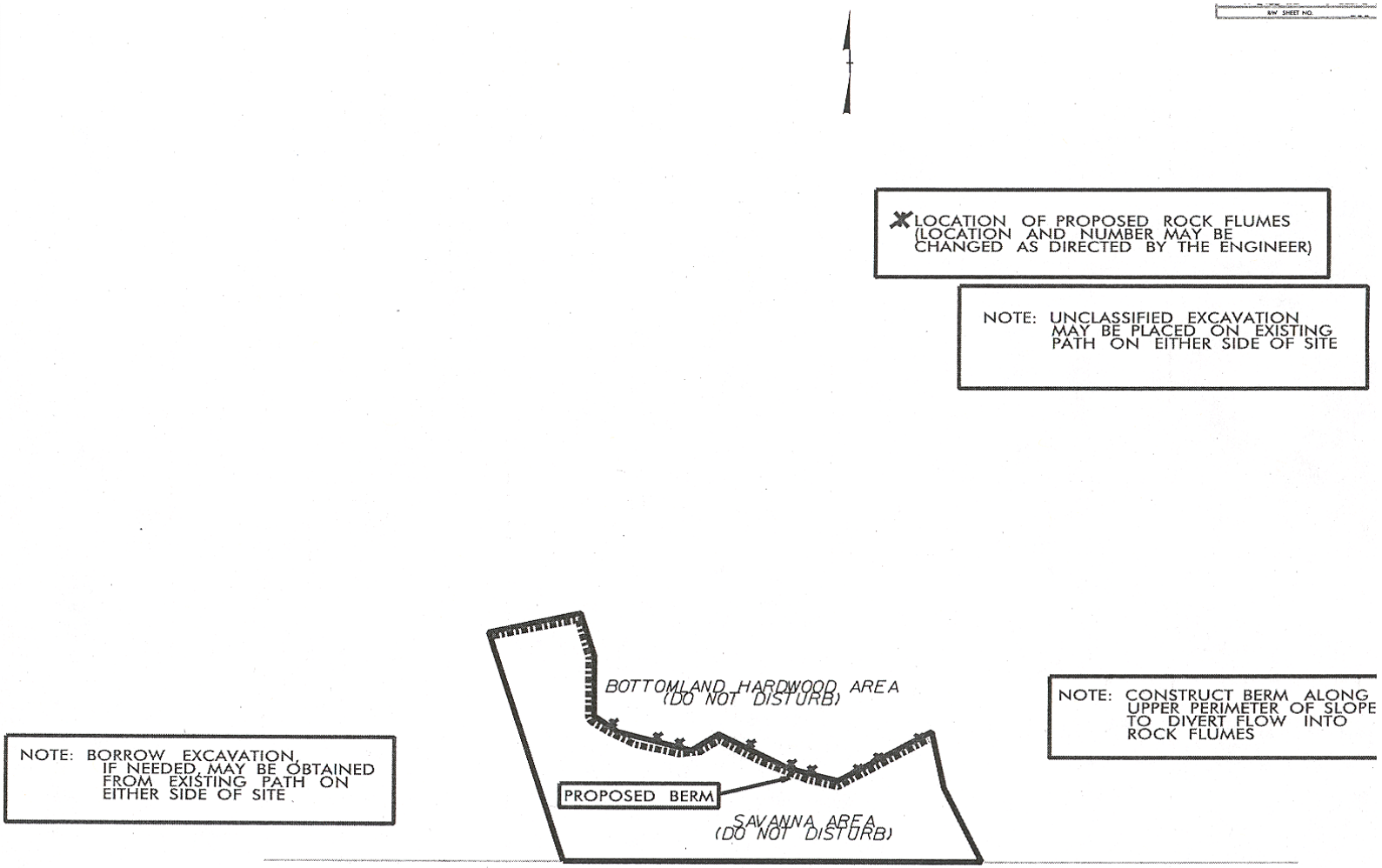
GENERAL NOTES:

-REPAIR EXISTING WASHOUTS AS DIRECTED

-GRADE EXISTING SLOPE TO 4:1

-CONSTRUCT BERM AROUND PERIMETER OF SLOPE

-CONSTRUCT ROCK FLUMES AS DIRECTED


R/W SHEET NO.
LOCATION OF PROPOSED ROCK FLUMES (LOCATION AND NUMBER MAY BE CHANGED AS DIRECTED BY THE ENGINEER)
NOTE: UNCLASSIFIED EXCAVATION MAY BE PLACED ON EXISTING PATH ON EITHER SIDE OF SITE
BOTTOMLAND HARDWOOD AREA (DO NOT DISTURB)
NOTE: CONSTRUCT BERM ALONG UPPER PERIMETER OF SLOPE TO DIVERT FLOW INTO ROCK FLUMES
NOTE: BORROW EXCAVATION, IF NEEDED, MAY BE OBTAINED FROM EXISTING PATH ON EITHER SIDE OF SITE
PROPOSED BERM
SAVANNA AREA (DO NOT DISTURB)