SOUTH BAY

LONG-TERM MONITORING OF PIEZOMETERS

AT SOUTH BAY MINE SITE

A report prepared for M. Kalin

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by

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October, 1998

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Introduction

Groundwater flow can constitute one of the major flow paths along which contaminants are transported away from a particular surface site. The surface site can, generally speaking, be relatively easily managed with the appropriate containment structures, flow and chemistry monitoring, etc. Accidental spills and escapes are generally immediately noticed and remedial measures are, in most instances, relatively easily implemented.

However, the liquid component of any waste stored at surface, unless very specific engineered measures are taken, is in contact with the underlying sediments. This scenario is the rule rather than the exception. Liquids with their contained contaminant load will infiltrate the underlying sediments. The degree and rate of infiltration is a multi-component function of the underlying sediments, the waste and the hydrogeological setting. Once the contaminants are incorporated in the groundwater, the hydrogeological environment will determine the rate and the direction of flow away from the surface containment area. Furthermore, it should be realized, that liquids, which infiltrate sediments and are incorporated in the groundwater flow system, will, with time, be discharged to the surface environment again.

In order to obtain a reasonable framework of the subsurface environment, test drilling is done to define the stratigraphy and piezometers are installed to obtain information on the hydraulic head and permeability distribution. In addition, water samples are taken to define the chemistry of the groundwater and to monitor the movement of the contaminants.

Groundwater flow is an essential component of the water budget and its chemistry in any given area. Groundwater flow differs from surface water flow by its inherent time delay. In other words, contaminant transport in surface water is, relatively speaking, immediate, while in the subsurface it is, generally speaking, very slow. This means, that although there is active groundwater contamination below a waste site, it can take many years before it re-occurs at surface some distance away from the site. This further means, that the monitoring requirements for the subsurface are unequivocally long-term.

Groundwater Monitoring at South Bay Mine Site.

Piezometers were first installed in 1986. Subsequently, an extensive test drilling and piezometer installation program was conducted in 1994/95. The water level of the piezometers was measured intensively from October 1986 – January 1988 (bI-monthly), intermittent monthly from 1988 – 1996 and on a regular monthly basis from early 1996 – present. A total of 62 piezometers, including 5 nests (more than 1 piezometers in same location) were installed in 1986, of the total, 9 have been destroyed. The operating piezometers are distributed as follows: 7 on the Mine Site, 18 outside the Tailings Basin and 26 inside the Tailings Basin. Of the 26 piezometers inside the Tailings Basin 10 are in the immediate vicinity of the concrete dams on the southwest side. The majority of the holes drilled for the piezometers did not penetrate bedrock, consequently most piezometers were completed relatively shallow. In addition, 8 shallow piezometers ("H" series) were constructed in the tailings in the southwestern part of the Tailing Basin. As a consequence of the lack of information on the stratigraphy, the configuration of the bedrock surface and the hydraulic head distribution, an extensive drilling and piezometer construction program was conducted in 1994/95. An additional 47 piezometers were installed. For special interests study a further 15 shallow piezometers ("sandpit" area) were constructed.

Review of Database.

It is obvious from the above, that a large number of piezometers exist, which requires a considerable effort and money to operate. The objectives of this review are:

1. Determine if data collection at all locations has to be continued for an understanding of the hydrogeological environment,

2. Prioritize the monthly measuring schedule, without seriously impacting the understanding of the hydrological environment, and

3. Determine which piezometers have to be measured to assess the impact of external activities (e.g. logging).

Ad. 1. Long-term Trend.

In order to assess Point 1, the long-term trend of the elevation of the water level in 24 piezometers installed in 1986 was considered. NOTE: the piezometers on the Mine Site are excluded from this review, because of drastic modifications made to the surface environment, e.g. Backfill Raise ditch, draining of Mill Pond, which has affected the long-term trend.

<u>North of Tailings Basin.</u> M1 is located near the outflow of Decant Pond and southeast of Mud Lake. M3 and M34 are situated west and south of the southern part of Mud Lake, respectively. The piezometers are completed at relatively shallow depth in sediments overlying the bedrock surface. Figure 1 shows the long-term trend of the elevation of the water level in these piezometers. As can be seen in this figure the overall trend is the same for all piezometers. All three piezometers show a significant rise each year during the Spring runoff and a subsequent decline. The lowest elevation of the water level is attained just prior to the Spring runoff. The decline is interrupted by significant rainfall events during the Summer and early Fall. The differences and similarities in the magnitude of the response to recharge events between the piezometers reflect not only differences in the local hydrogeological environment, but are also a function of the setting of the local hydrogeological environment within the regional surface and subsurface environment.

In order to determine if there has been a decline or incline in the long-term trend, comparison of the elevation of the water levels versus time during a "quasi steady state" should only be considered. This is the period where there is no longer any direct input from precipitation into the subsurface. Optimum for such a comparison would have been the time period from January to Spring Runoff. All things being equal, a rise or decline in the elevation of the water level during this time period would indicate a change in the input parameter, i.e. precipitation or at the local level a change in the physical environment. However, few years over the period 1986-1998 have data for this time interval. It was, therefore, decided to evaluate the months of October and November. In this area snowfall generally occurs in September and daytime temperatures drop to below 0 ^{0}C in the month of October. Under these conditions the ground surface becomes frozen and further infiltration of precipitation is stopped or at least minimized. The month of November should, in all likelihood, reflect the beginning of the “quasi steady state” period. It should be pointed out, that the water levels in November would show the effect of significant differences in the sum total of Spring runoff and rainfall more strongly than the water levels in March of the following year. Also a significant precipitation event just prior to freeze-up would still be reflected in the general decline trend. The perceived trend should, therefore, only be considered in a qualitative sense.

Figure 2 shows the elevation of the water level in October and November for the period 1986-1998. The trend of elevation of the water level in both M3 & M34 is very similar for both months and remains more or less the same over the period for November, but shows slightly greater variation for October. M1 follows the same trend. The difference between M1 and M3/M34 remains more or less the same over the period 1986-1990, but shows a considerable increase over the period from 1993-1998. The latter is due to an increase in the level of Decant Pond. This has been pointed out in a previous report.

<u>West-Southwest of Tailings Basin.</u> M28 is located west of the Tailings Basin but east of a topographic divide between the Tailings Basin and Confederation Lake. M50 is situated southwest of the Tailings Basin and between the shoreline and the previously mentioned topographic divide. Both piezometers are deep and completed in sand and gravel sediments immediately overlying the bedrock surface. In addition, M54 is shown, which is a shallow piezometer (0.75m deep) on the shore of Confederation Lake. This latter piezometer reflects the water level of Confederation Lake.

Figure 3 shows the long-term trend and Figure 4 the elevation of the water levels in October and November of the piezometers. The long-term trend (Fig. 3) as well as the trend for October and November (Fig. 4) is similar for the piezometers. Also the differences between various pairs of piezometers remain approximately the same.

<u>South of Tailings Basin</u>. M20B and M21 are located south of the Tailings Basin near the old town site. M20B is completed in bedrock, while M21 is completed in sand and gravel sediments immediately overlying the bedrock surface. Both piezometers can be considered deep.
The long-term trend of the elevation of the water level in these piezometers (Fig. 5) is essentially identical both in terms of amplitude and magnitude. A slight increase in the overall trend of the elevation of the water level appears to be present. However, if the October and November water levels are considered (Fig. 6), they appear to remain more or less the same.

<u>Northern Part of Tailings Basin</u>. M1 and M33 are outside the Tailings Basin, while M2 and M31 are located just north of Decant Pond within the Tailings Basin. M1 is situated in the outflow area of Decant Pond and M33 is located in a recharge area for the Tailings Basin. All piezometers are considered shallow and completed in surficial sediments.

Figure 7 shows the long-term trend of the elevation of the water level in these piezometers. As can be seen in this figure, the trend of the elevation of the water level in

M1, M2 & M30 remains more or less the same over the period 1986-1991, but show a definite increase from 1993-1998 in M2 and M30 and a more subdued increase in M1. M2 shows a much more muted response to recharge events than the other piezometers. This is due to its close proximity to Decant Pond. M33 only follows the trend of the other piezometers for the period 1986-1991, but the latter period shows a declining trend.

The above observations are also present in the trend of the elevation of the water level in October and November (Fig. 8). The increase in the elevation of the water level in M1, M2 & M30 is due to an increase in the level of Decant Pond. This has been pointed out in a previous report.

Central and Northwestern Part of Tailings Basin. Piezometers M4 and M30 are located immediately south of the northwestern dyke, while M26A is situated immediately west of Decant Pond and M41 is located in the middle of the northwestern part of the Tailings Basin. All piezometers are considered shallow. M4 and M30 are completed in sand, M26A in tailings and M41, based on the permeability, appears to be completed in tailings.

The long-term trend of the elevation of the water levels is plotted in Figure 9. All piezometers show the same response to recharge events, but differ in their character. It is obvious, that the trend in the elevation of the water level of M26A and M30 shows an increase for the period 1993-1998. M41 appears to remain more or less the same, while M4 shows a decrease.
M4 and M41 have essentially the same surface elevation and the screened interval in both piezometers is also completed at the same elevation, but their trends are totally different. The stratigraphic section at M4 (TH2) shows that this piezometer is completed in a medium grained sand below the tailings. Although a thin layer of muskeg (20cm) is present in the section some distance below the piezometer, it does not appear to impede the flow of groundwater towards the deeper part of the aquifer. The stratigraphic information at M41 is not well defined, but the permeability of the completion zone is about 3 orders of magnitude lower than M4, which strongly suggests tailings, muskeg or clayey silt. Information from other piezometers show, that piezometers completed in tailings, which directly overly vertically continuous sand deposits, generally have elevations of the water level much lower than piezometers completed in tailings or very fine grained sands which are underlain by clay or thick sections of muskeg. The clay layer and to a lesser extent muskeg acts as an effective barrier to downward movement of groundwater and the flow of groundwater is essentially lateral in the tailings, until the edge of the barrier is reached.

M30 shows a noticeable change in the response to recharge events between the period 1986-1990 and 1993-1998. The latter period shows a considerable loss of the magnitude of the response to recharge events. This is due to the effect of flooding in the vicinity of M30, which in turn is caused by an increase in the elevation of the water level of Decant Pond.

The elevation of the water levels versus time in October and November is shown in Figure 10. This figure shows that M4, M26A and M30 remain more or less the same over the period 1986-1990, but M26A & M30 show a significant increase in the elevation of the water level over the period 1993-1998, while M4 shows a gentle drop over this period. The change in M26A & M30 is due to an increase in the elevation of the water level of Decant Pond. The trend of the water levels in M26A, M30 and M4 is similar for

October and November. M41 shows a totally different behavior between October and November over the period 1986-1998. This strongly suggests that M41 may not have attained a state of “quasi steady state” in November.

West Side of Tailings Basin. M5W, M27S and M24W, three shallow piezometers, are located along the western edge of and inside the Tailings Basin. The surface elevation is about the same and the screened interval in the piezometers is also completed at the same elevation. All three piezometers are completed in sediments under the tailings, M5W in a silty sand, which overlies a clay bed and M27S in the top part of a thick section of muskeg. M24W is completed in a fine grained sand, which is the upper part of a continuous channel fill. No clay or muskeg beds occur at this locality. The permeability of the completion zone in the piezometers is very similar.

The long-term trend of the water levels is shown in Figure 11. As can be seen in this figure the trend of piezometers M5W and M27S is the same and appears to show an overall increase in the elevation of the water level, while the trend for M24W shows a slight decrease.
The elevation of the water level in M5W and M27S is considerably higher than in M24W. Piezometers M5W and M27S are located between M24W and M4. A comparison of Figures 9 and 11 shows that the overall trends and the elevation of the water level in M4 and M24W are essentially identical. Furthermore, the latter two piezometers are completed in sediments, which are continuous with the deeper part of the aquifer. Both M5W and M27S are separated from the underlying aquifer by a permeability barrier and it becomes very obvious, that the stratigraphy below the completion interval plays a major role in the magnitude of the elevation of the water level in piezometers.

The trend of the elevation of the water levels in October and November is plotted in Figure 12. M5W and M27S show no obvious trend in October, but the November data seems to suggest an increase in the elevation of the water level. M24W shows a decreasing trend for both October and November.

Southeast Side of Tailings Basin. In this area a number of concrete dams has been build between the Tailings Basin and the adjoining Boomerang Lake. A large number of piezometers have been installed in this area, both inside and outside of the dams. Figure 13 shows the long-term trend of the elevation of the water level in two piezometers (M7S & M9) inside the Tailings Basin and two piezometers (M45 & M47) outside the Tailings Basin and the concrete dams. The trend of each pair of piezometers is the same. The piezometers inside the Tailings Basin show an overall increase in the elevation of the water level, while M45 & M47, outside the Tailings Basin, show little or no change. The significant difference in the elevation of the water level between the two pairs of piezometers is the direct result of the presence of a vertical impermeable or low permeable barrier, i.e. the concrete dams.

Figure 14, which shows the long-term trend of the elevation of the water level in October and November, confirms that the elevation of the water level inside the Tailings Basin has increased since at least 1993. This increase is due to an increase in the elevation of Decant Pond.

Piezometer Pairs in Tailings Basin. A number of piezometer pairs were installed in the Tailings Basin during 1986. Only two pairs have a shallow and a relatively deep piezometer. These are M5W & M5E and M7N & M7S, respectively. M5E is completed in the lower part of the aquifer and below the clay layer at this locality. The meager stratigraphic information for the M7 location shows the absence of any clay, but possibly the presence of a thin organic layer (muskeg?). Figure 15 shows the long-term trend of the elevation of the water level in the piezometers, while Figure 16 shows the trend in October and November versus time. Both figures clearly show that the overall elevation of the water level in M5E, the deep piezometer, has remained more or less the same, while the other piezometers show a definite increase in the elevation of the water level. Again, proximity to Decant Pond and subsurface stratigraphy determines the overall trend of the elevation of the water levels.

Piezometers M10 and M44. The long-term trend of the elevation of the water level in these piezometers is plotted in Figure 17. The behavior of the water level in both piezometers shows that the piezometers are seriously plugged and are not functioning properly.

"H" Series of Piezometers inside Tailings Basin. Eight piezometers fall under this series. They are all shallow piezometers completed in the tailings. For ease of viewing, the piezometers are split in two groups: H1, H2, H3 & H4 and H5, H6, H7 & H8. The stratigraphic section in the area, where these piezometers are located, is not known, except for H8. At this locality, the tailings are underlain by a thick section of Muskeg (2.3m), which in turn overlies a thick clay bed (2.5m).
The long-term trend of the elevation of the water level in these piezometers is plotted in Figure 18 and 20, respectively. The trend in October and November is shown in Figures 19 and 21, respectively. In general, all piezometers show an increase in the elevation of the water level for the period 1993-1998. The group of piezometers (H5, H6, H7 & H8) closest to Decant Pond shows the greatest increase.

General Observations

The overall character of the long-term trend of the elevation of the water level is very similar. The amplitude of the response to a particular recharge event varies with changes in the local hydrogeological environment and its setting within the regional one.

Piezometers completed outside the Tailings Basin show that the overall elevation of the water level remains more or less the same during the late Fall and Winter months over the period from 1986-1998. The gentle increases and decreases, observed in November, reflect, in all likelihood, differences in annual recharge.

Piezometers completed within the Tailings Basin behave similar to the ones outside the basin over the period 1986-1990. Over the period 1993-1998, the elevation of the water level in the piezometers close to Decant Pond and those shallow piezometers, wherever located in the Tailings Basin, which are underlain by a permeability barrier show an increase. This increase is caused by the increase in the elevation of the water level of Decant Pond.

Ad 2. Prioritize the monthly monitoring.

The above review of the long-term trends of the water levels in various parts of the South Bay Site shows that for the understanding of the behavior of the hydrogeological environment the number of measuring sites can be sharply reduced. However, and there is always a "however", this depends till a large degree on what future actions are undertaken. This point will be discussed in more detail below.

A number of piezometers M36, M37, M58, M59, M60A & B, M61, M62, M63, M71 and M72A, B & C are measured on an intermittent basis and located in areas with difficult access. Furthermore, several of these piezometers freeze during the winter months. These piezometers could be dropped from the monthly water level monitoring network. However, they are and remain important points for water quality monitoring. Sampling of these sites should be conducted on a yearly basis during the time when "quasi steady state " groundwater flow conditions exist. If significant changes in groundwater quality are detected then the piezometers should be included again in the monitoring program.

Similarly, piezometer M22, M50, M54, M55, M56 and M77A & B located west and southwest of the topographic divide between the Tailings Basin and Confederation Lake could be dropped from the monthly water level monitoring, but yearly water samples should be taken. If significant changes in groundwater quality are detected then the piezometers should be included again in the monitoring program.

A large number of piezometers have been installed in the vicinity of the concrete dams, which are located in the southeastern part of the Tailings Basin. Figures 22 and 23 show the elevation of the water level over the period October 1986 – January 1988 and March 1996 – July 1998, respectively. The piezometers with much lower elevation of the water level (M8, M45 & M47) are located outside the dams and between the Tailings Basin and Boomerang Lake. A comparison of the figures shows, that the relative position of the trace of the elevation of the water level in the various piezometers has not changed, except for M7N. In 1987 M7N had about the same elevation as M7S, but in 1996-1998 M7N is considerably higher, which is due to the rise in Decant Pond. The vertical order of the traces shows a classic example of a recharge area (upstream of the dams), where the trace of successively deeper piezometers shows a lower plotting position, except for M9. The reverse is true for piezometers M8, M45 & M47, which are located in the discharge area (downstream of the dams). M9 has a relative low elevation of the water level, it is approximately 0.5m lower than M7N and 1.3m lower than H3. Part of this relatively low water level may be due to stratigraphic position of the completion interval (i.e. below the tailings and apparently in sand and gravel). However, it is suspected, that the main cause is a significant seep at the southwestern end of the dam.
It is suggested that only M7N & S, M8, M9, M32 and M47 be measured on a monthly basis. All piezometers should be measured for three consecutive months, preferably during late Fall or early Winter, to determine if any major changes have occurred.

The piezometers, in the western and northwestern part of the Tailings Basin and the adjoining sandpit and gravel pit should all be measured monthly, including M28.
M3, M66B and M90 can be dropped.

M39A represents an anomaly. M39A is located between M69 and M79 and the elevation of the water level should be higher than M79. However, compared to M79 it has a lower or the same elevation of the water level. Furthermore, M39A is consistently lower than M80 & M81 (Fig. 24). It is suspected that the collar elevation of M39A is incorrect. A transit or level survey should be conducted to tie M39A in to M79, M80, M69 and M5C. If the collar elevation is correct (i.e. the water levels), then not all contaminated water from the Tailings Basin flows through "Kalin" Canyon but is partially diverted.

Southwest of the Tailings Basin, M78A & B, M82 and M21 should be measured. M20A can be dropped, but should be water sampled once a year.

Northeast of the Tailings Basin M1 & M33 as well as M2 & M31 should be measured. M68 can be dropped but retained as a water sampling point.

The deep piezometers M26B, M40A and M75, not covered in the above discussion, should be measured.

The shallow piezometers M26A, M30, M41, M 65 and the "H" Series do not necessarily have to be measured anymore, provided the status quo of a high water level in Decant Pond is maintained. The effect that this high water level has on the watertable in a large part of the Tailings Basin, as well as on the piezometers near the concrete dams (e.g. M7N & S), has been shown extensively in the above reviews.

It is a well-known fact, that a relative increase in the elevation of the water level between two points increases the hydraulic head, in other words the flow rate. It is, therefore, strongly suggested that the water level in Decant Pond be lowered again to the 1986 level. If this scenario is followed, than the water levels in the shallow piezometers have to be measured again to monitor the effectiveness of the draining of Decant Pond.
If it is suspected, that geochemical changes are taking place, which could affect the permeability of the sediments (tailings), lowering of the watertable would also be advantageous, because it would provide a more rapid assessment of the effect of geochemical changes.

Piezometer M25 provides an excellent measure of the changes in the water level of Decant Pond and as such is a very important measuring point. Access to this piezometer has become difficult, which has resulted in a loss of data. An effort should be made to provide year around access to this piezometer.

The piezometers on the Mine Site should be measured on a monthly basis for at least another year to monitor the effect of the draining of Mill Pond. An integral part would be water sampling prior and after the Spring runoff.

Ad. 3. External Activities.

Logging of the big hill, east of the Tailings Basin and north of Boomerang Lake, is going to affect the water balance of the area. Evapo-transpiration would be sharply reduced, which would increase the elevation of the watertable in the area. This in turn would increase the amount of recharge to the Tailings Basin. Any associated potential increase in hydraulic head would increase the rate of groundwater flow and ultimately the rate of discharge into Mud Lake. If logging of this hill is likely to occur within the next couple of years, monthly measurements of the water level in several of the piezometers in the Tailings Basin should be continued to provide the necessary and required background data.

CONCLUSIONS

The long-term trend of the elevation of the water levels is pretty well defined. The total area considered here responds more or less homogeneous. Individual differences between piezometers are the result of differences between local hydrogeological environments and/or in the setting of the local hydrogeological environment within the regional surface and subsurface environment.

The elevation of Decant Pond exerts a considerable influence on the elevation of the water levels within the Tailings Basin.

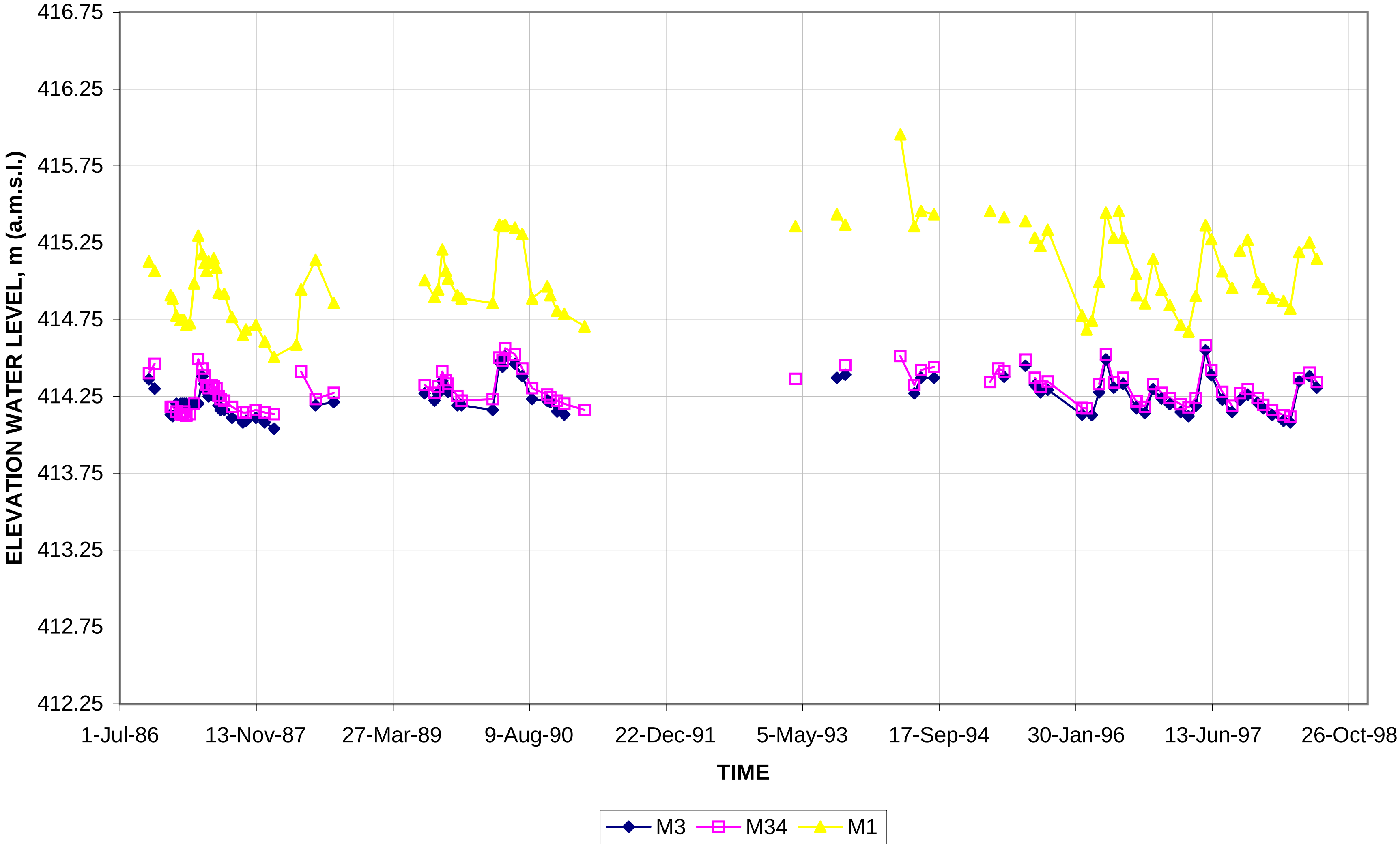
Any area, which constitutes an actual or potential pathway for the migration of contaminants, should be monitored continuously. (Town site, concrete dams, northwestern part of Tailings Basin and Decant Pond outflow area).

Piezometers dropped from the monthly measuring schedule should be water sampled at least twice. Once before Spring runoff and during the late Summer/early Fall.

All piezometers on the Mine Site as well as seeps should be monitored monthly. Regular water samples should also be taken.

The extent of the monthly monitoring of the shallow piezometers within the Tailings Basin will depend on what further actions are undertaken within the basin (draining of Decant Pond) and outside the basin by third parties (logging).

FIGURE 1. LONG-TERM TREND IN ELEVATION OF WATER LEVEL OF PIEZOMETERS: M3 & M34 OVER PERIOD OCTOBER 1986 - JULY 1998



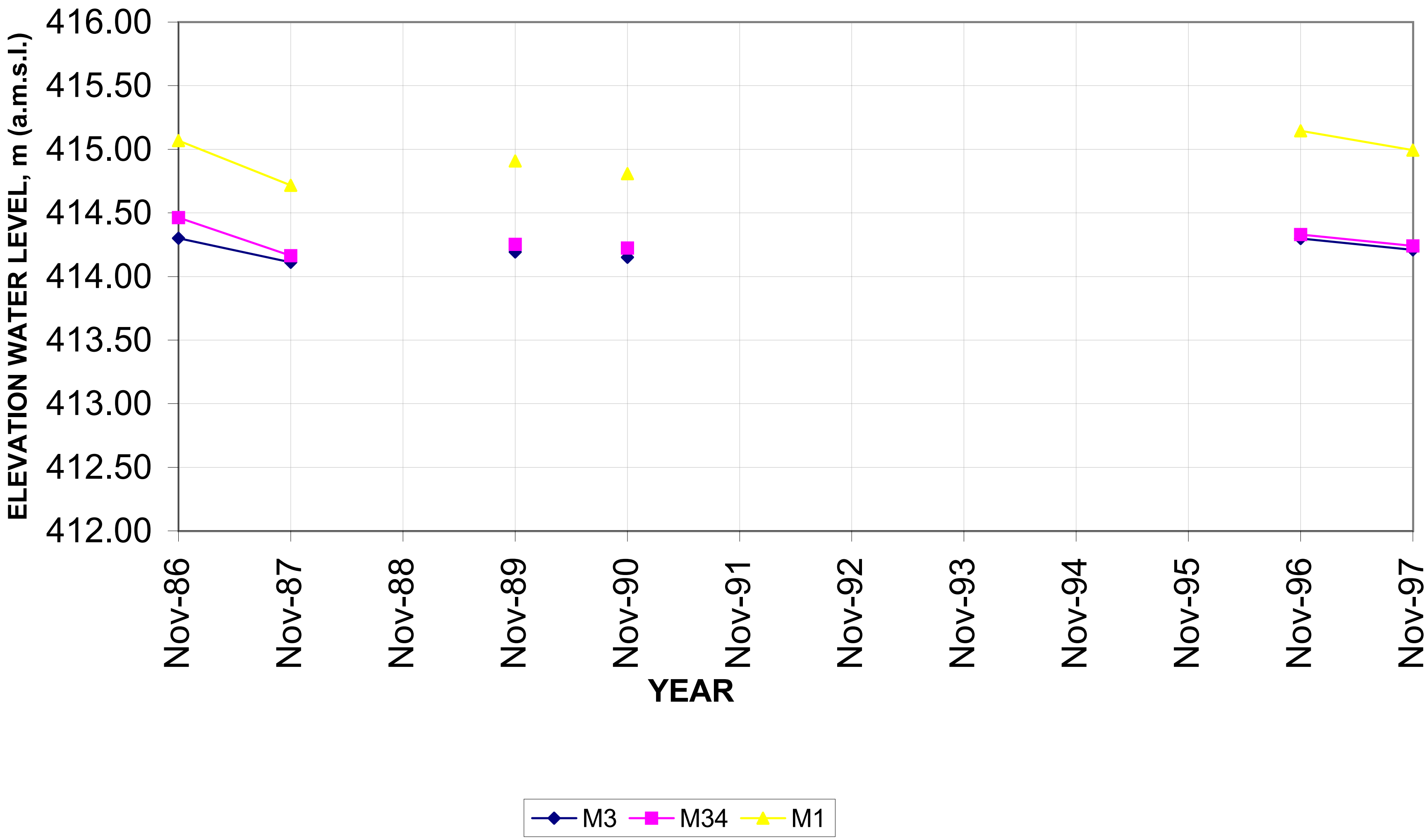
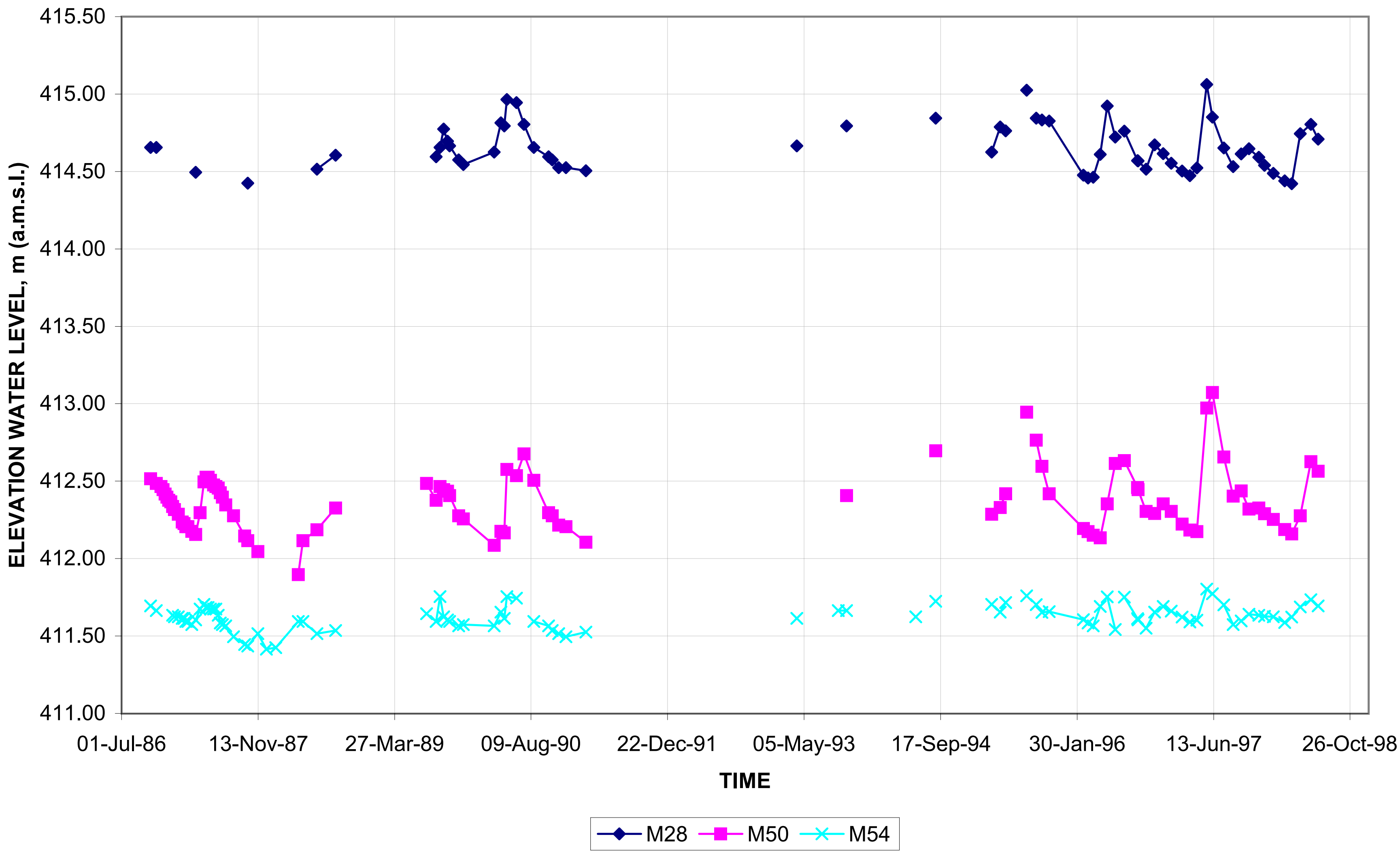


FIGURE 2. ELEVATION OF WATER LEVEL IN PIEZOMETERS M1, M3 & M34 IN OCTOBER AND NOVEMBER OVER PERIOD 1986-1997

FIGURE 3. LONG-TERM TREND IN ELEVATION OF WATER LEVELS OF PIEZOMETERS: M28, M50 & M54 OVER PERIOD OCTOBER 1986 - JULY 1998



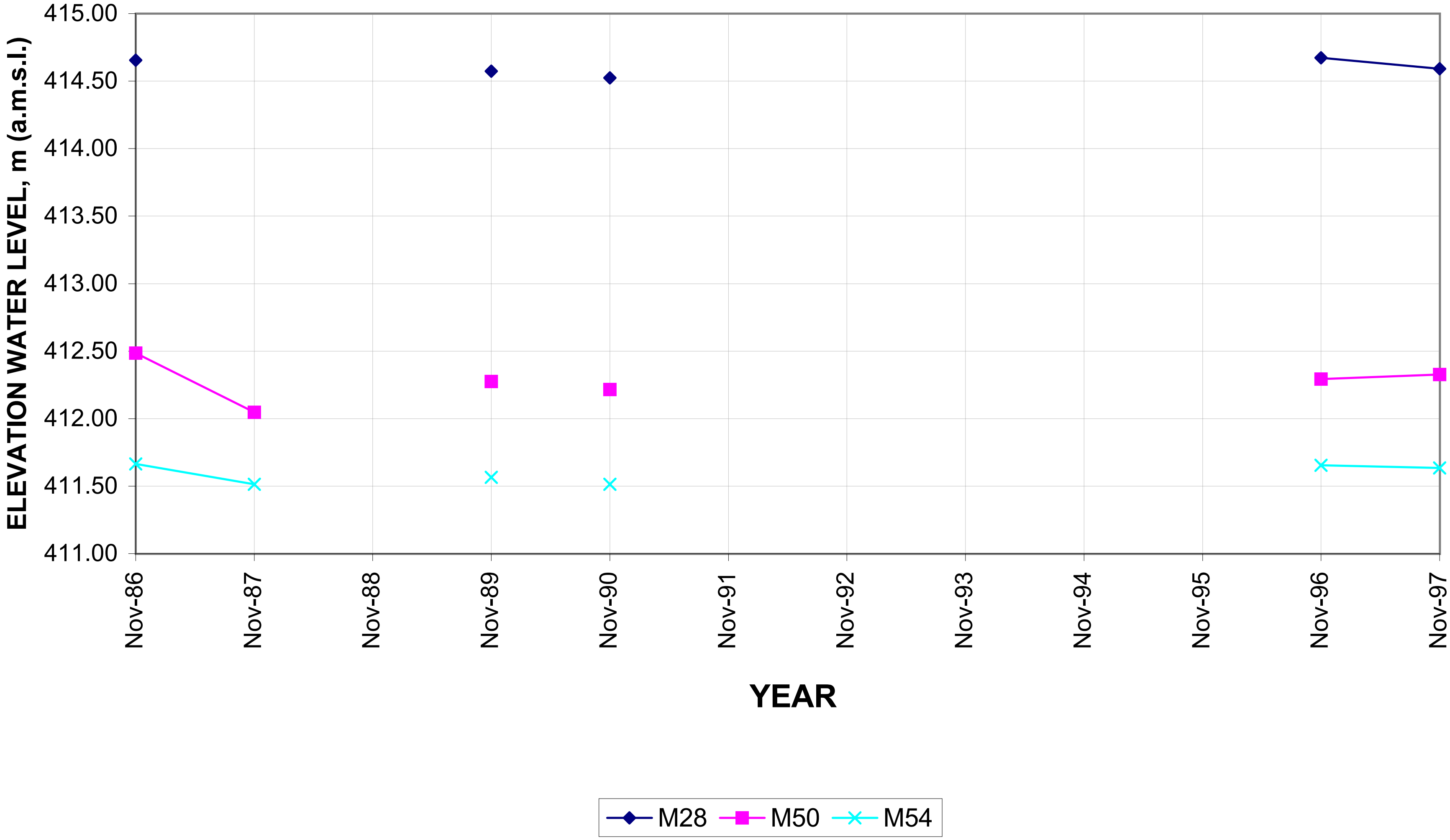
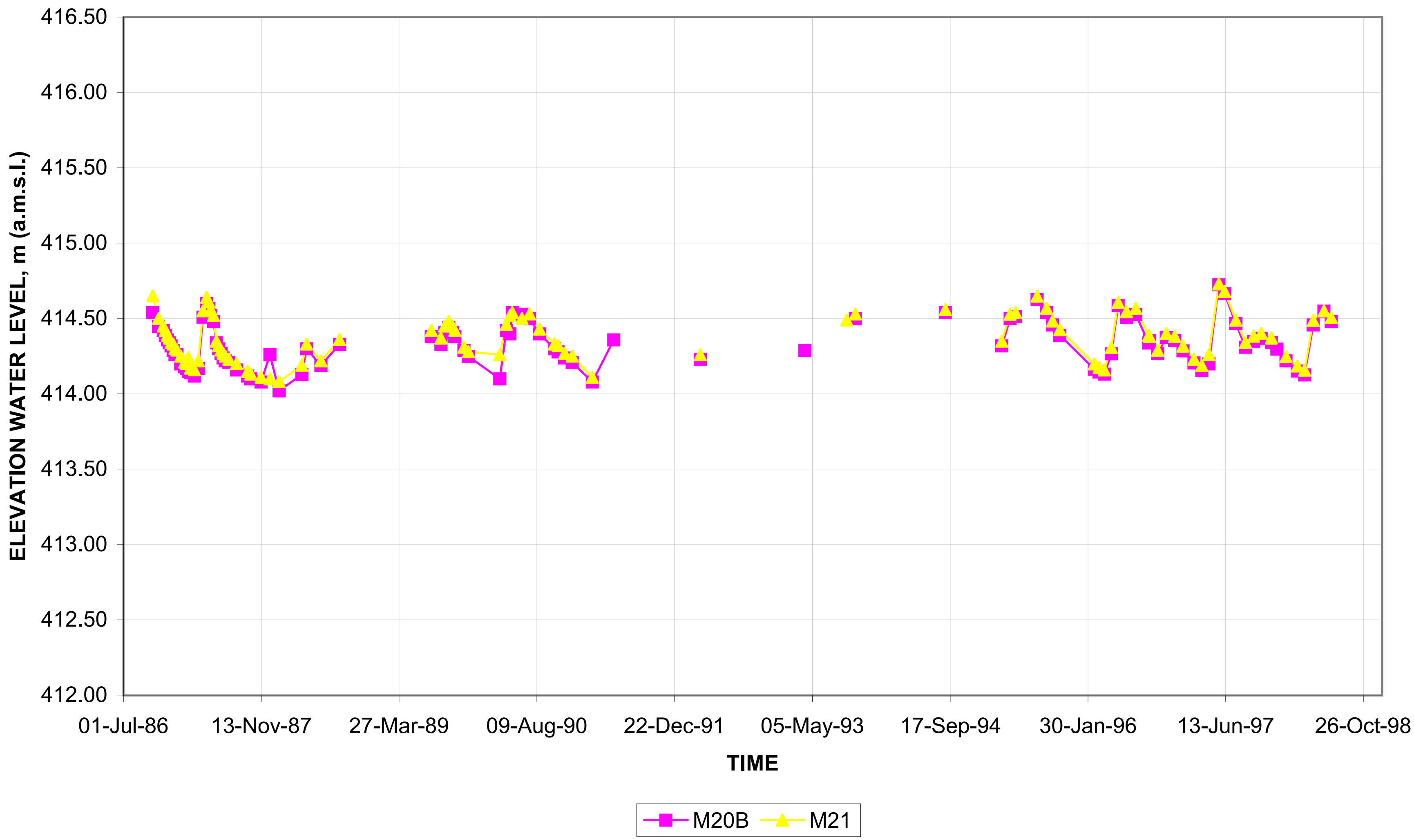


FIGURE 4. ELEVATION OF WATER LEVEL IN PIEZOMETERS M28, M50 & M54 IN OCTOBER AND NOVEMBER OVER PERIOD 1986-1997

FIGURE 5. LONG-TERM TREND IN ELEVATION OF WATER LEVEL IN PEZOMETERS: M20B & M21 OVER PERIOD OCTOBER 1986 - JULY 1998



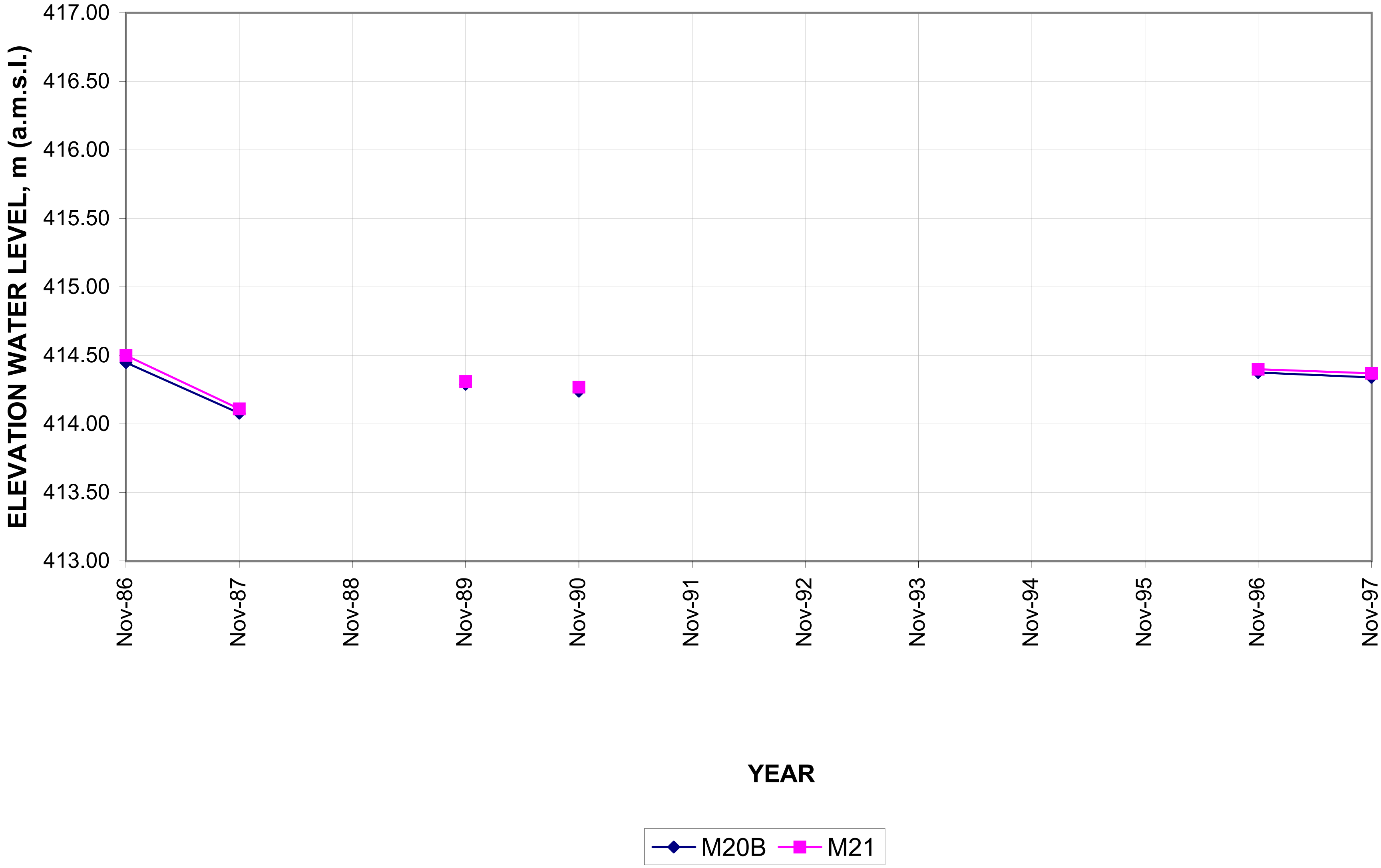
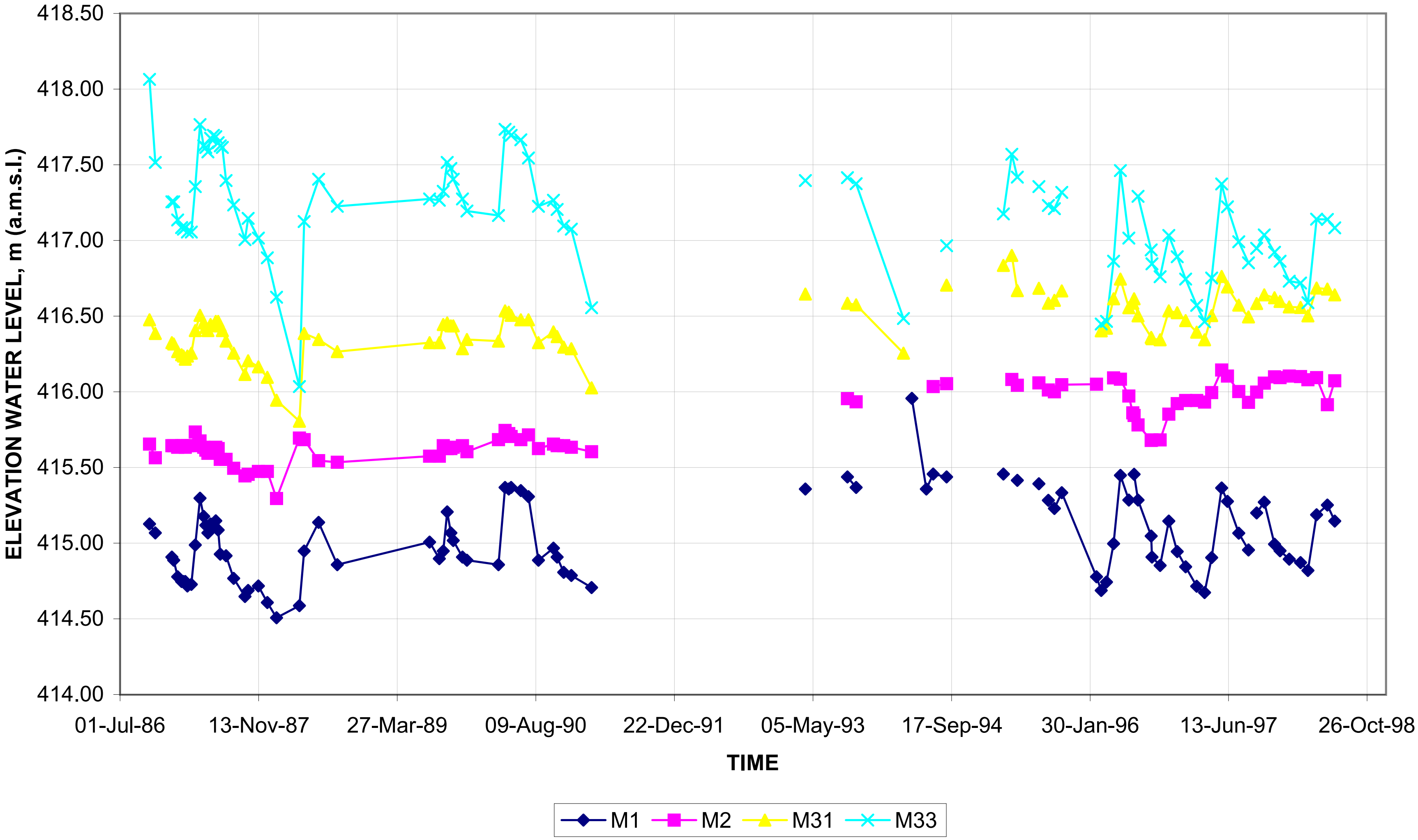


FIGURE 6. ELEVATION OF WATER LEVEL IN PIEZOMETERS M20A & M21 IN OCTOBER AND NOVEMBER OVER PERIOD 1986 - 1997

FIGURE 7. LONG-TERM TREND IN ELEVATION OF WATER LEVELS OF PIEZOMETERS: M1, M2, M31 & M33 OVER PERIOD OCTOBER 1986 - JULY 1998



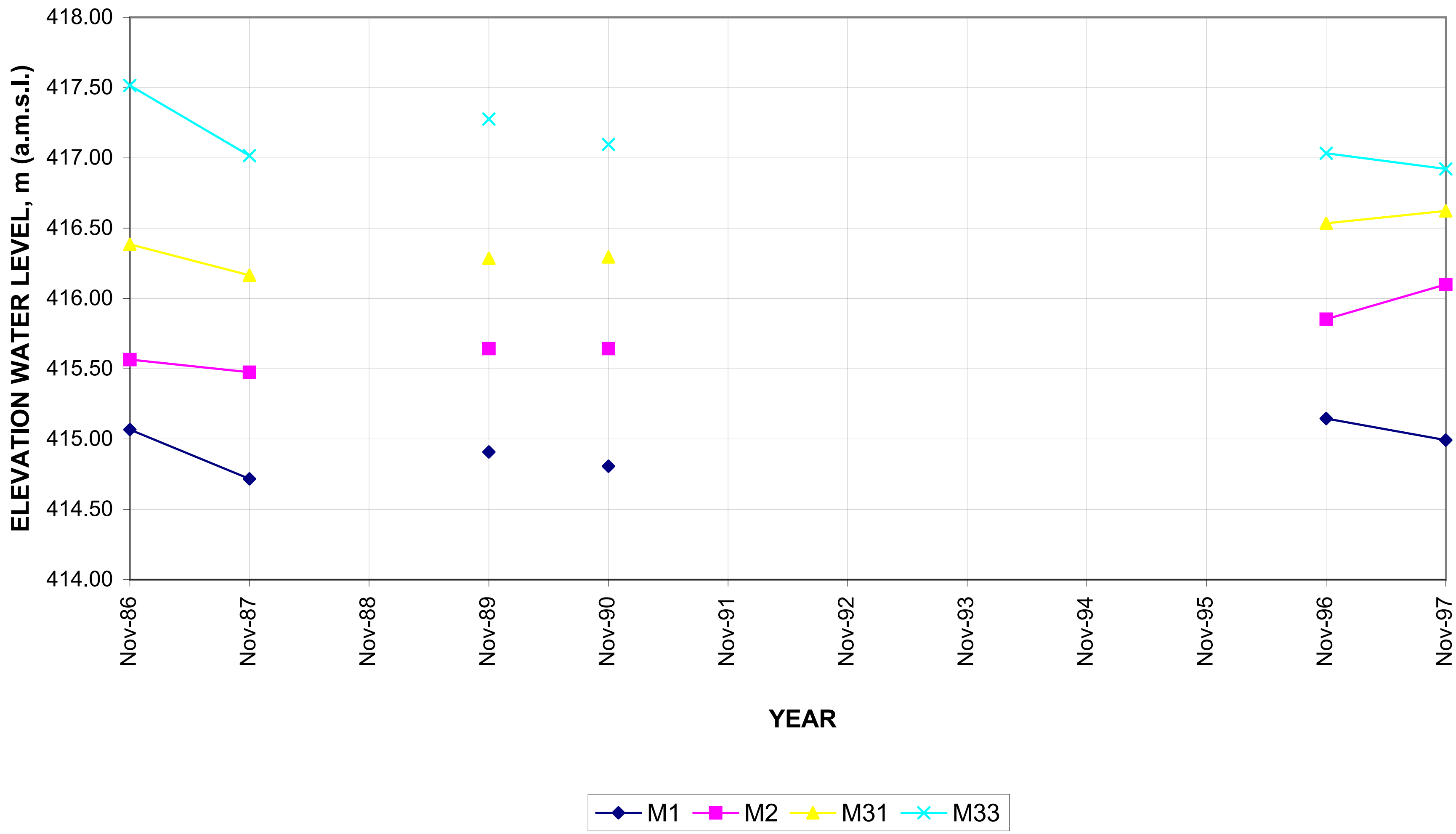
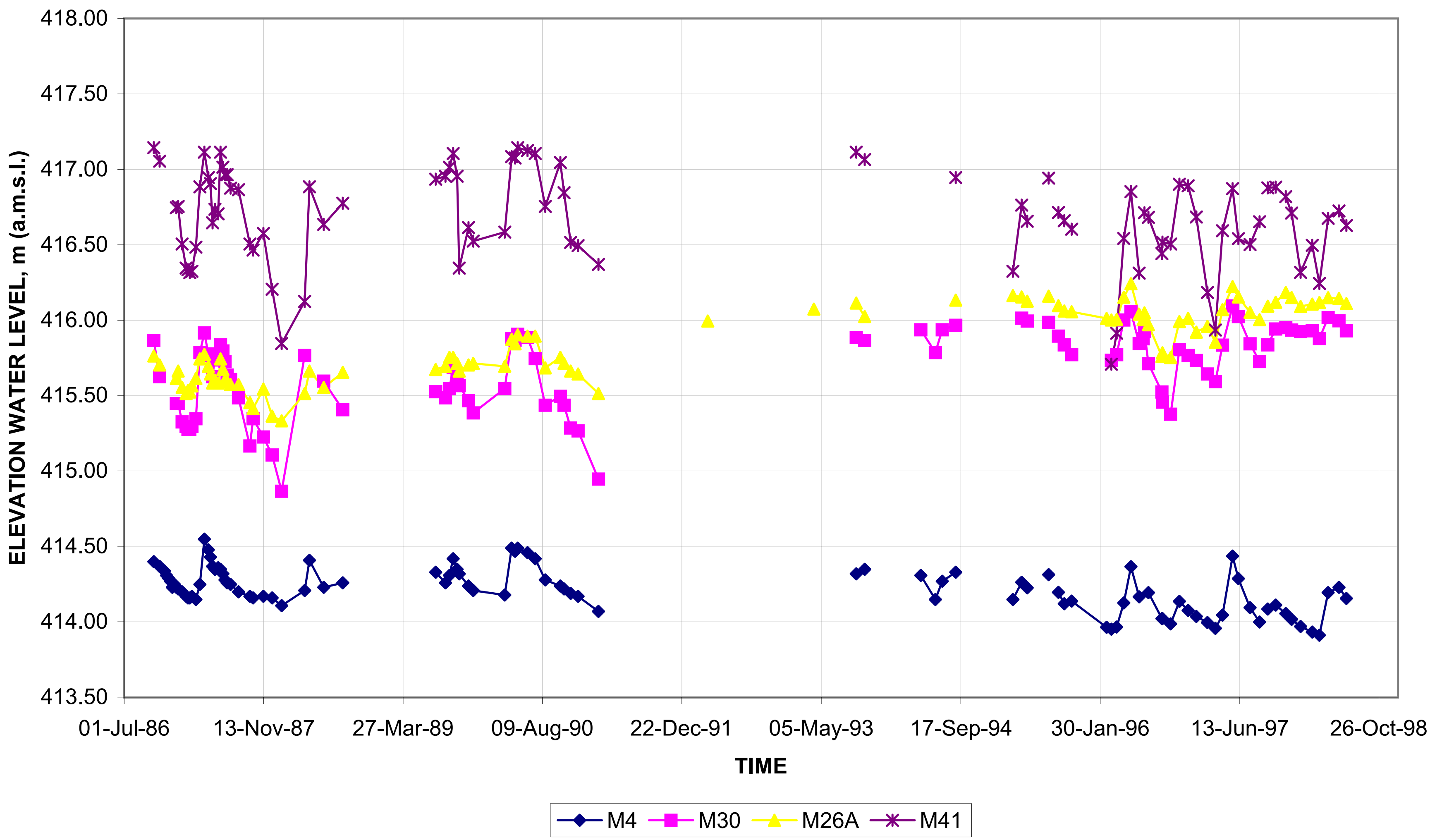


FIGURE 8. ELEVATION OF WATER LEVEL IN PIEZOMETERS M1, M2, M31 & M33 IN OCTOBER AND NOVEMBER OVER PERIOD 1986-1997

FIGURE 9. LONG-TERM TREND IN ELEVATION OF WATER LEVELS IN PIEZOMETERS: M4, M26A, M30, & M41 OVER PERIOD OCTOBER 1986 - JULY 1998



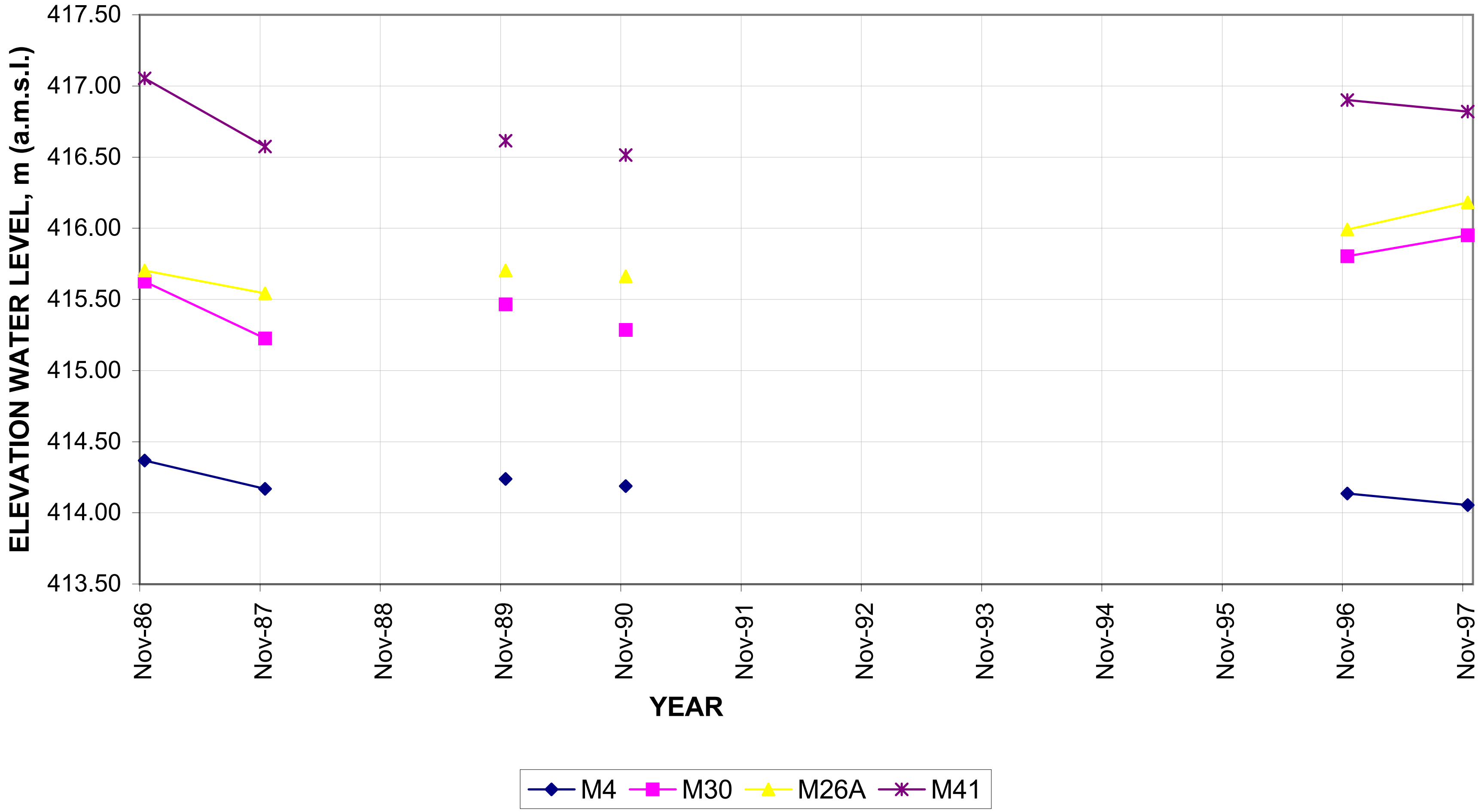
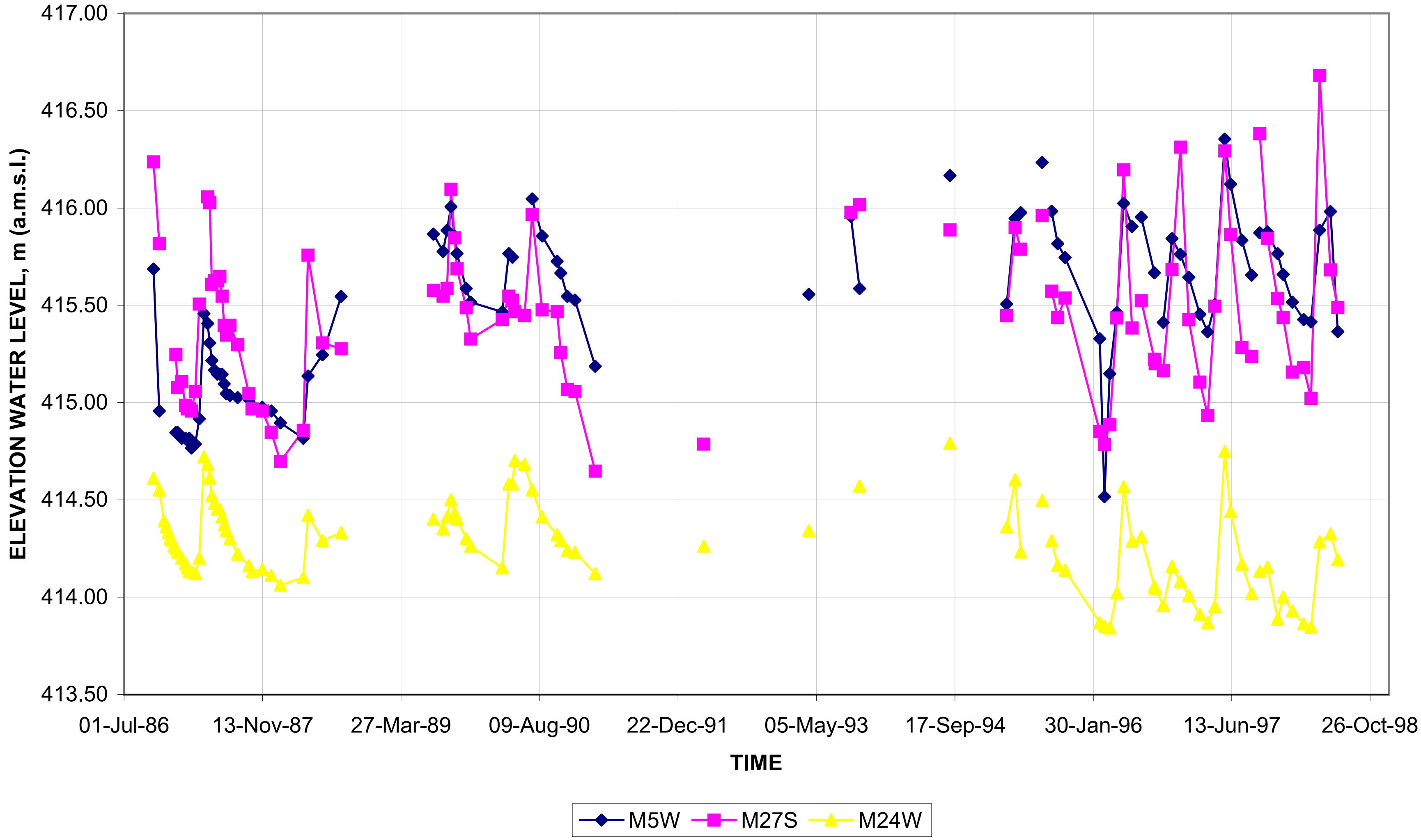


FIGURE 10. ELEVATION OF WATER LEVEL IN PIEZOMETERS M4, M30, M26A, M40A & M41 IN OCTOBER AND NOVEMBER OVER PERIOD 1986 - 1997

FIGURE 11. LONG-TERM TREND IN ELEVATION OF WATER LEVEL IN PIEZOMETERS: M5W, M24W & M27S OVER PERIOD OCTOBER 1986 - JULY 1998



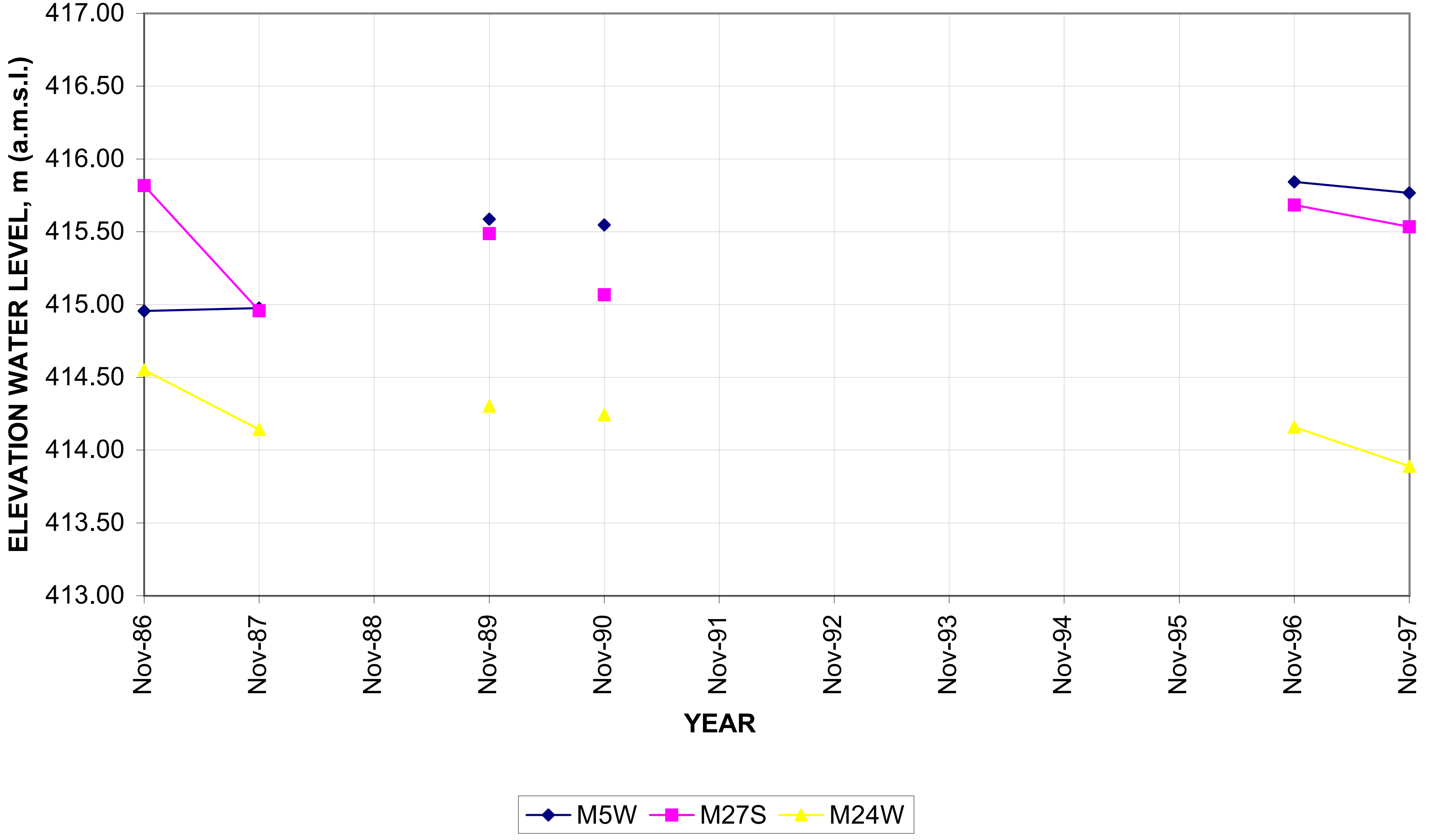
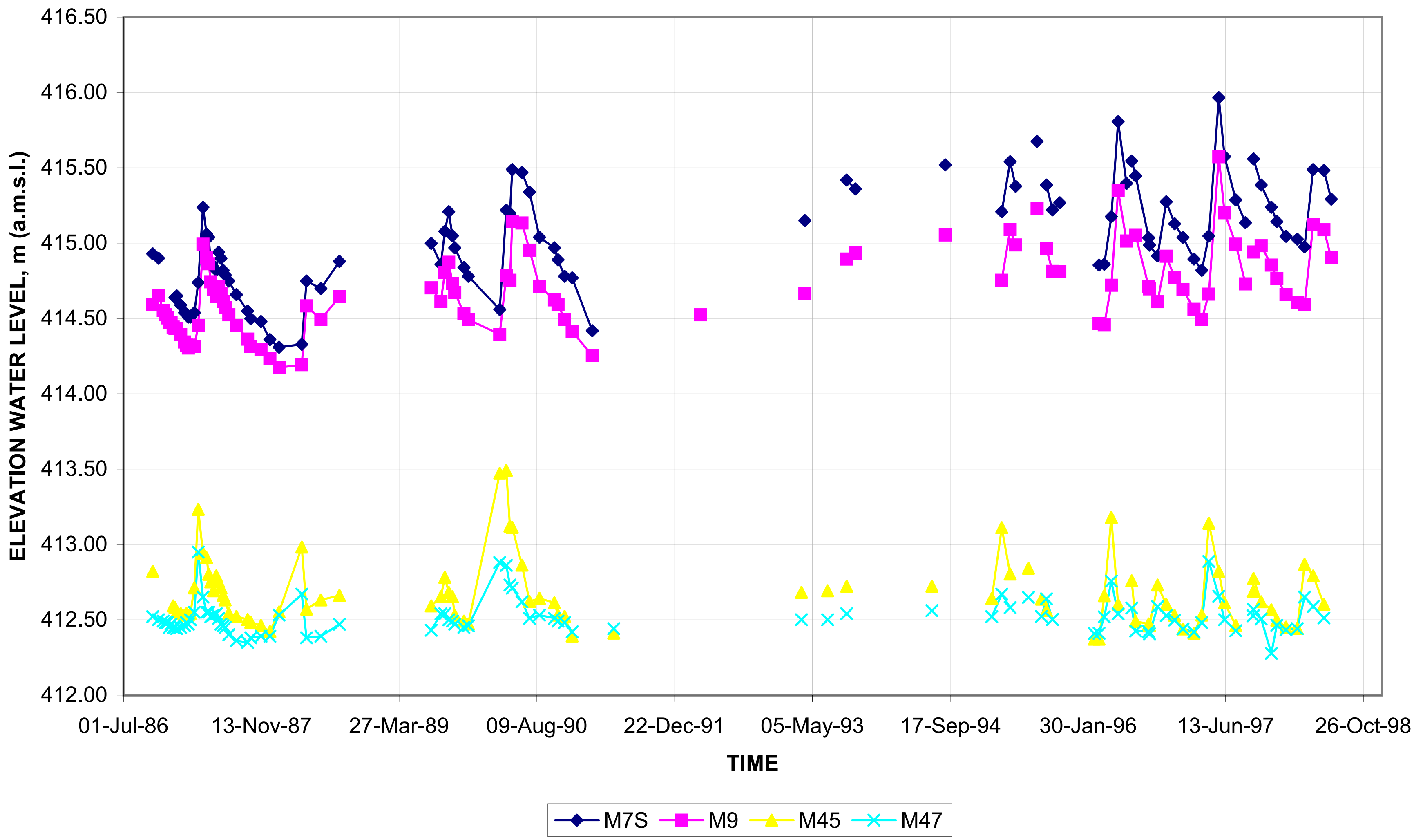


FIGURE 12. ELEVATION OF WATER LEVEL IN PIEZOMETERS M5W, M27S & M24W IN OCTOBER AND NOVEMBER OVER PERIOD 1986 - 1997

FIGURE 13. LONG-TERM TREND IN ELEVATION OF WATER LEVELS PIEZOMETERS: M7S, M9, M45 & M47 OVER PERIOD OCTOBER 1986 - JULY 1998



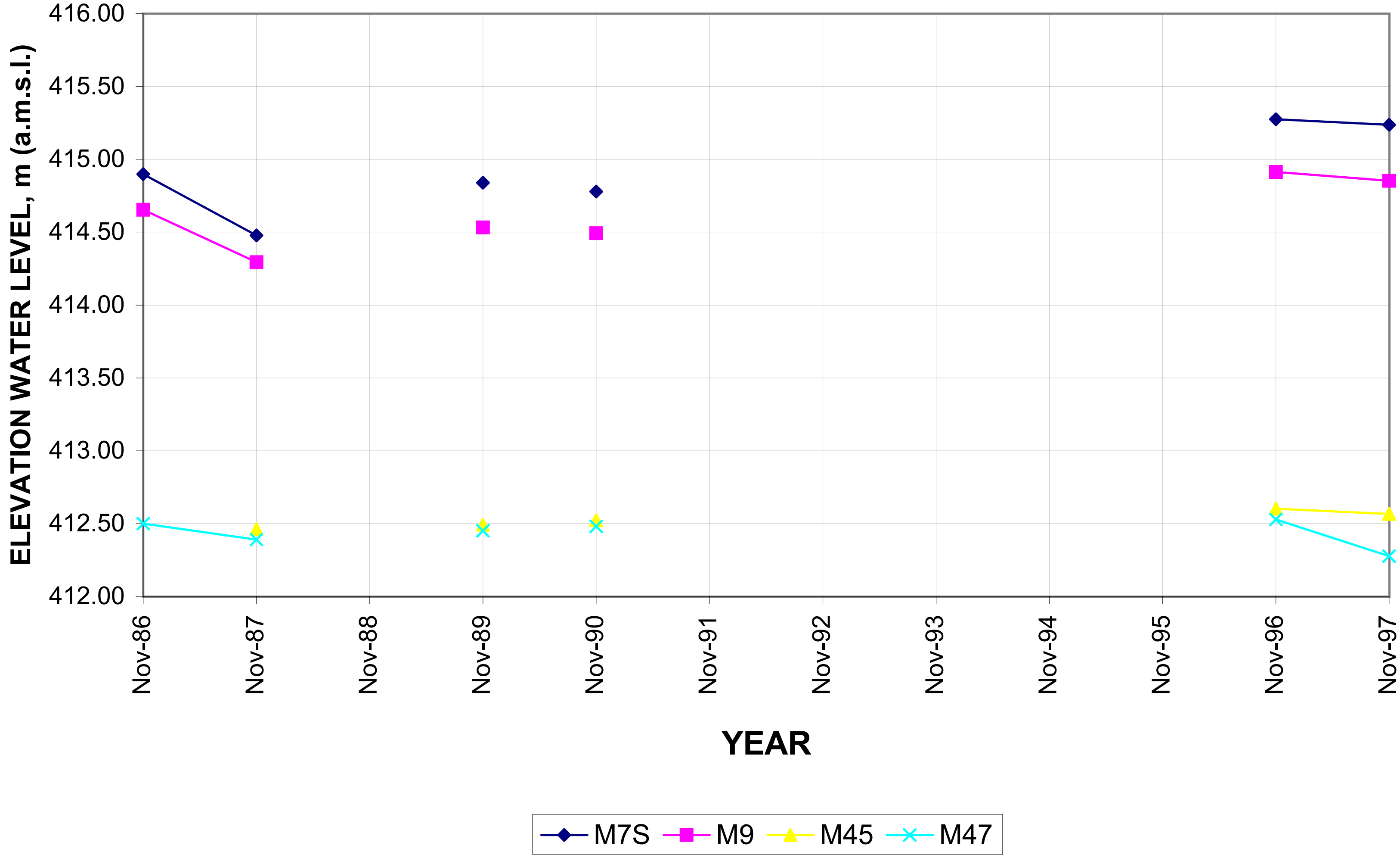
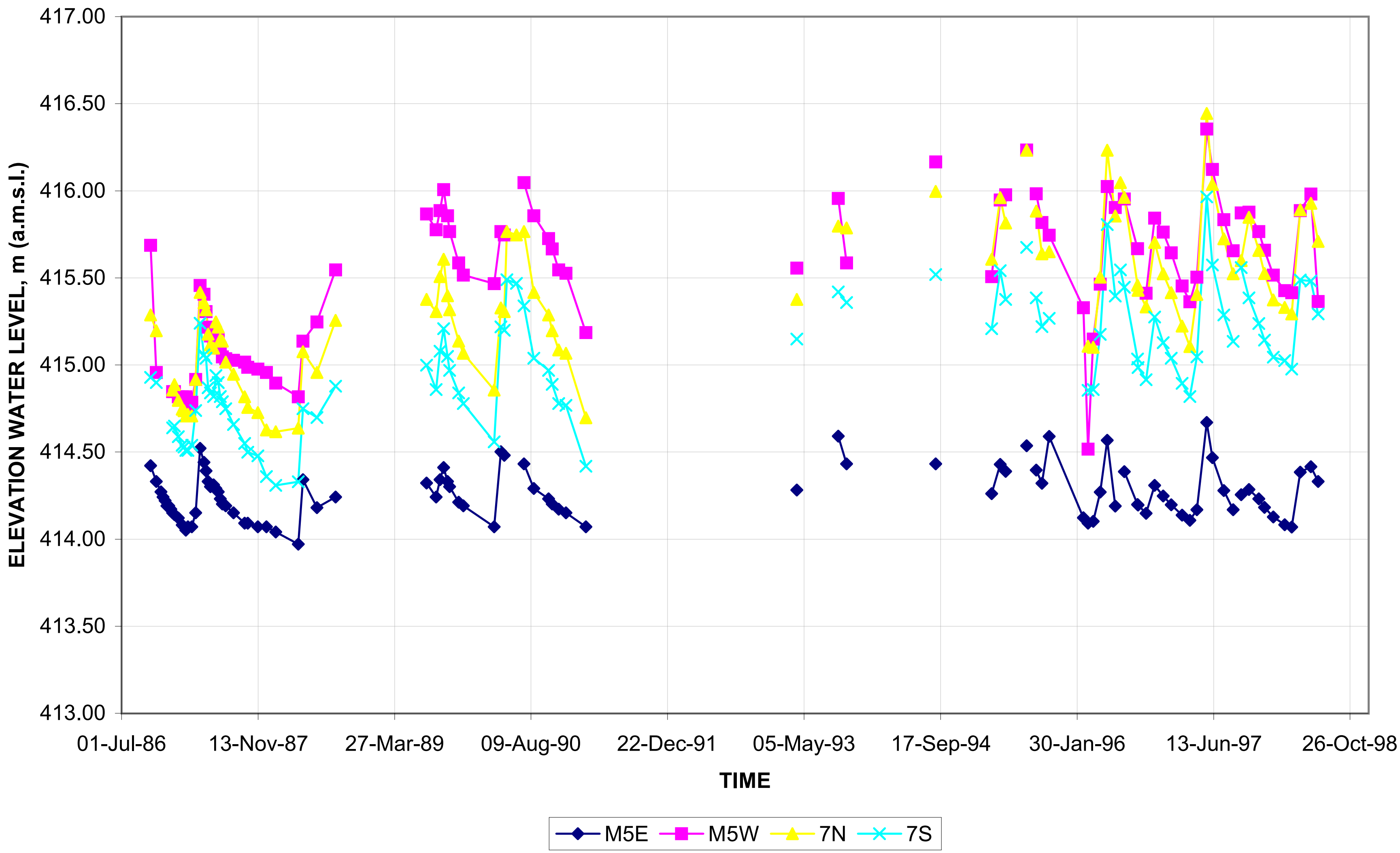


FIGURE 14. ELEVATION OF WATER LEVEL IN PIEZOMETERS M7S, M9, M45 & M47 IN OCTOBER AND NOVEMBER OVER PERIOD 1986-1997

FIGURE 15. LONG-TERM TREND IN ELEVATION OF WATER LEVEL OF PIEZOMETERS: M5W & M5E AND 7N & 7S OVER PERIOD OCTOBER 1986 - JULY 1998



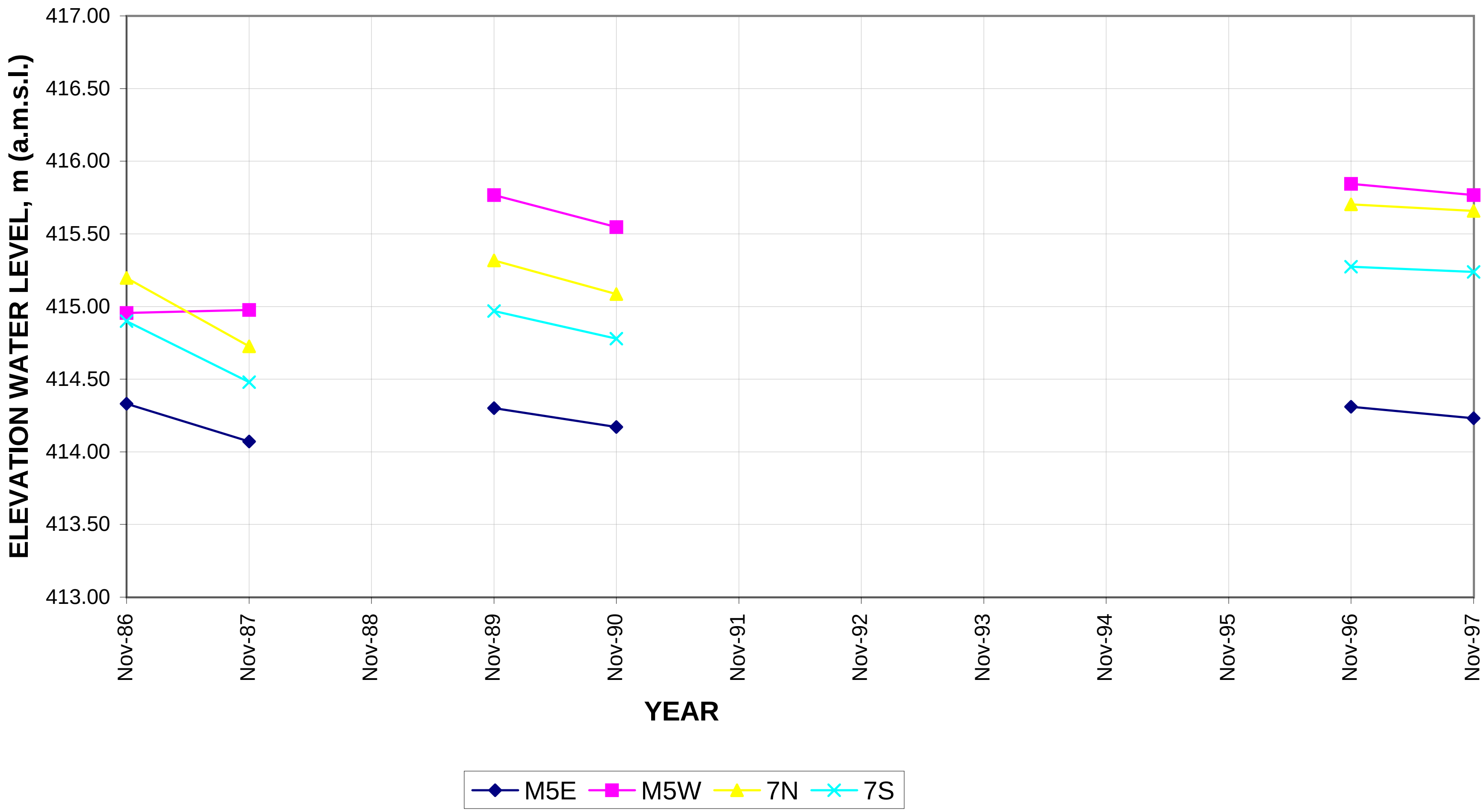


FIGURE 16. ELEVATION OF WATER LEVEL IN PIEZOMETERS M5W, M5E, M7N & M7S IN OCTOBER AND NOVEMBER OVER PERIOD 1986-1998

FIGURE 17. LONG-TERM TREND OF ELEVATION OF WATER LEVEL IN PIEZOMETERS: M10 AND M44 OVER PERIOD OCTOBER 1986 - JULY 1998

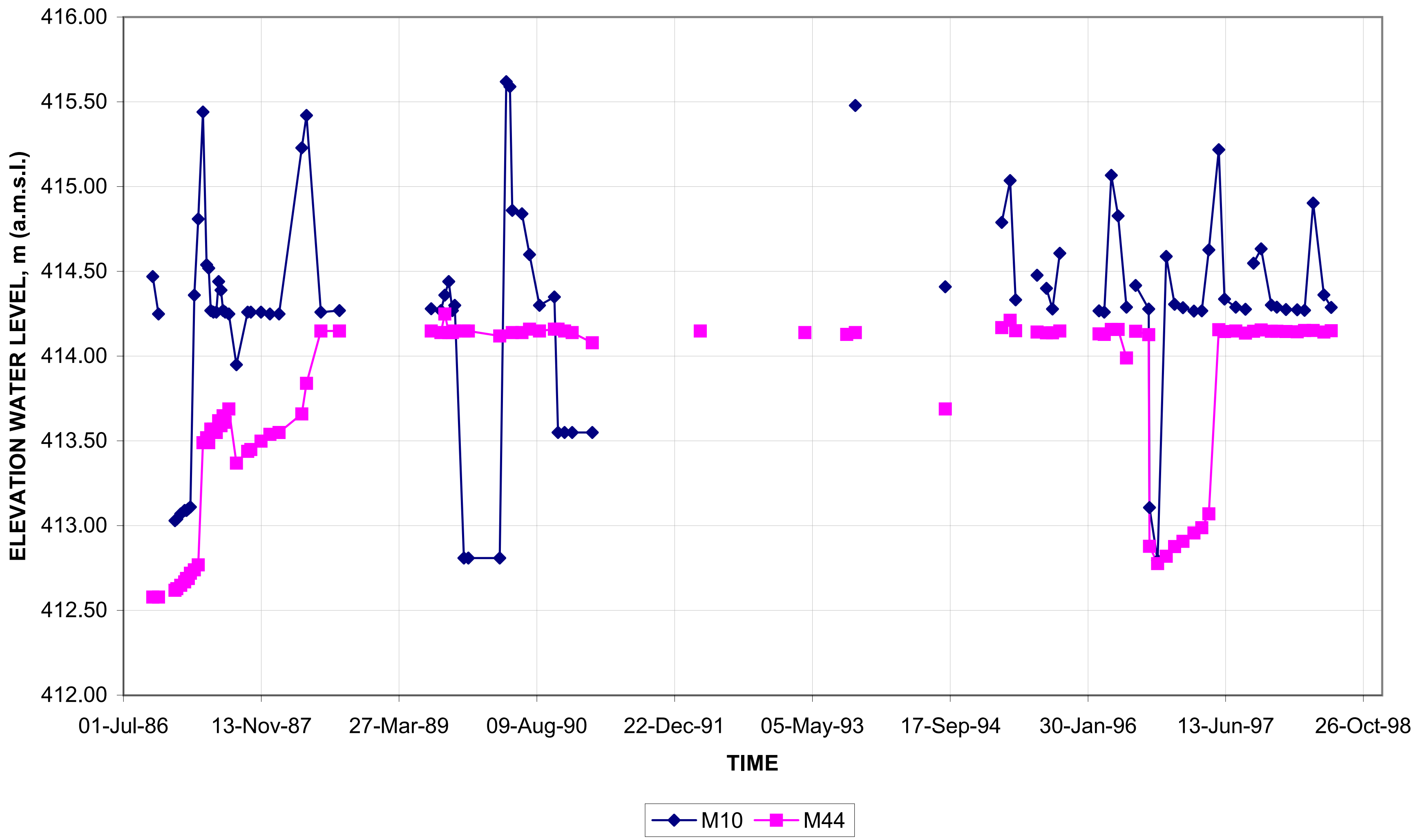
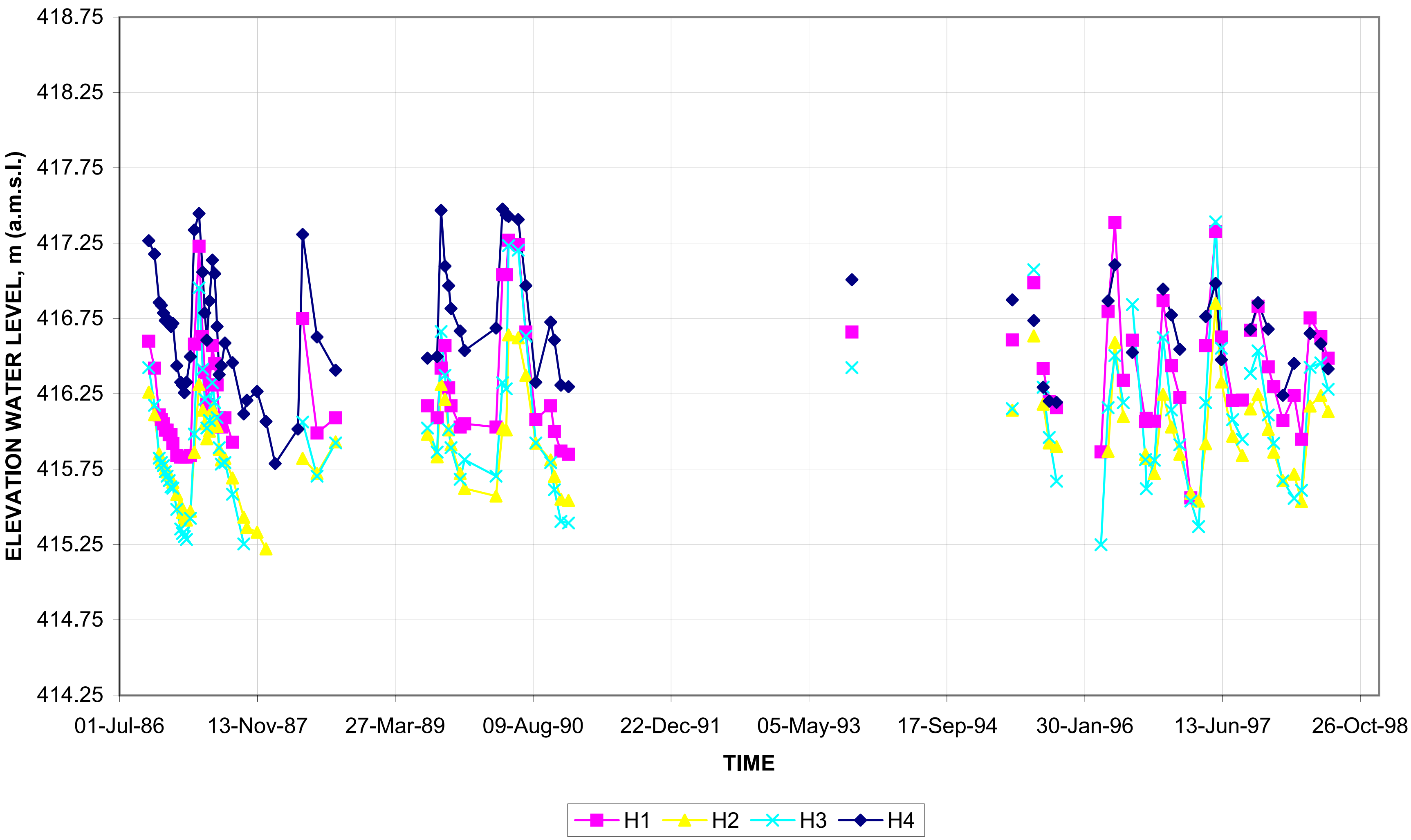


FIGURE 18. LONG-TERM TREND OF ELEVATION OF WATER LEVEL IN PIEZOMETERS: H1, H2, H3 & H4 OVER PERIOD OCTOBER 1986 - JULY 1998



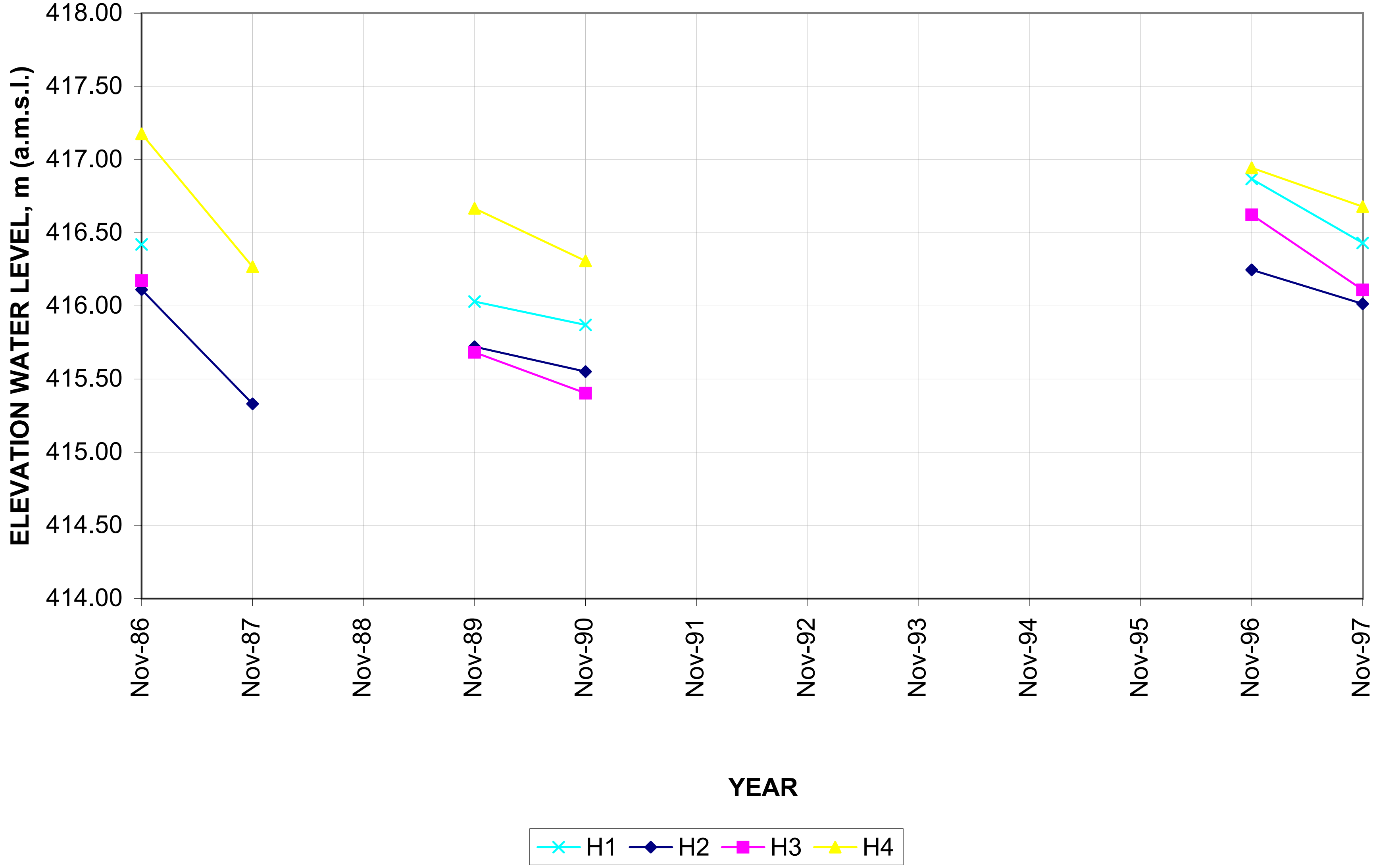
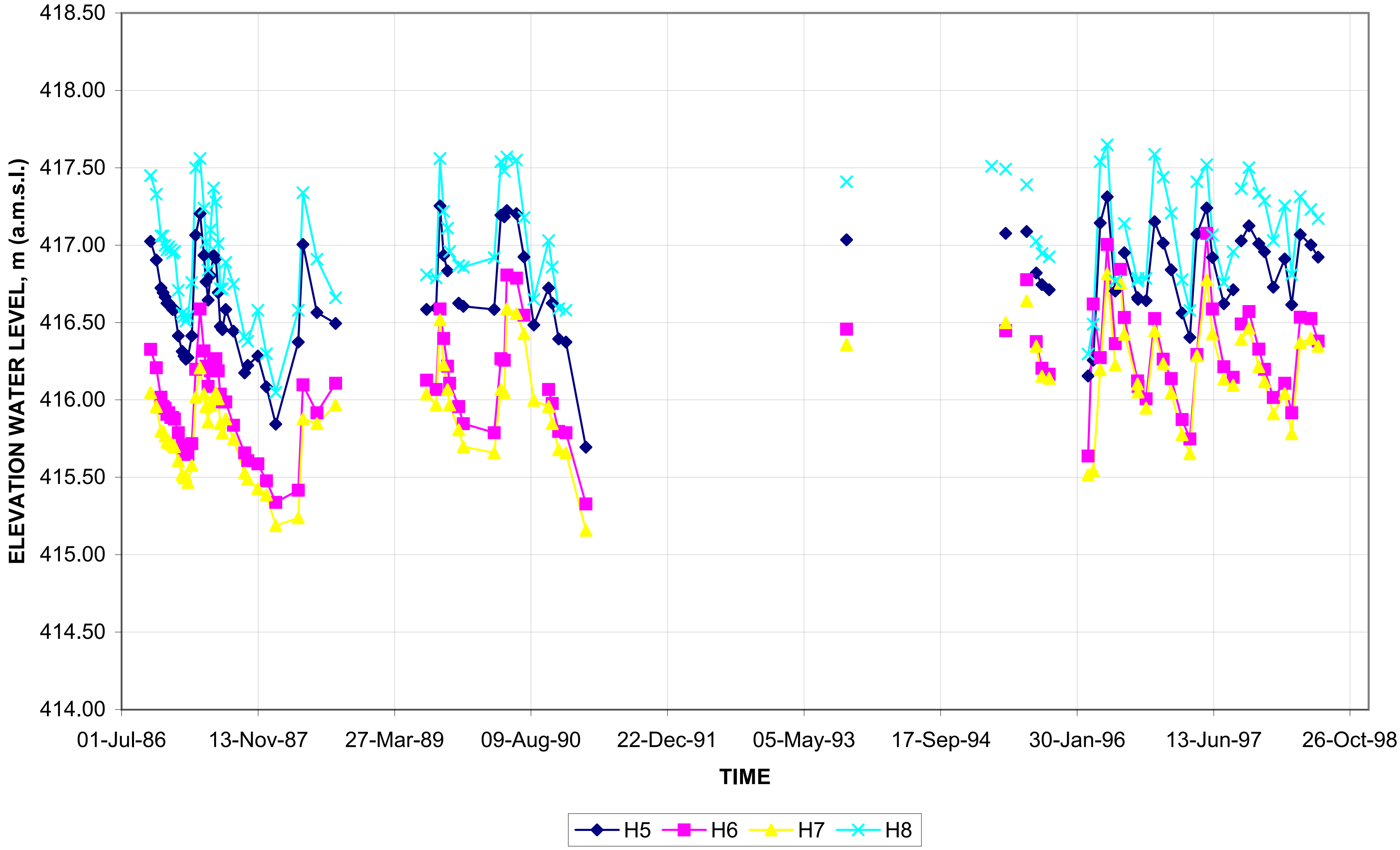


FIGURE 19. ELEVATION OF WATER LEVEL IN PIEZOMETERS H1, H2, H3 & H4 IN OCTOBER AND NOVEMBER OVER PERIOD 1986 - 1997

FIGURE 20. LONG-TERM TREND OF ELEVATION OF WATER LEVEL IN PIEZOMETERS: H5, H6, H7& H8 OVER PERIOD OCTOBER 1986 - JULY 1998



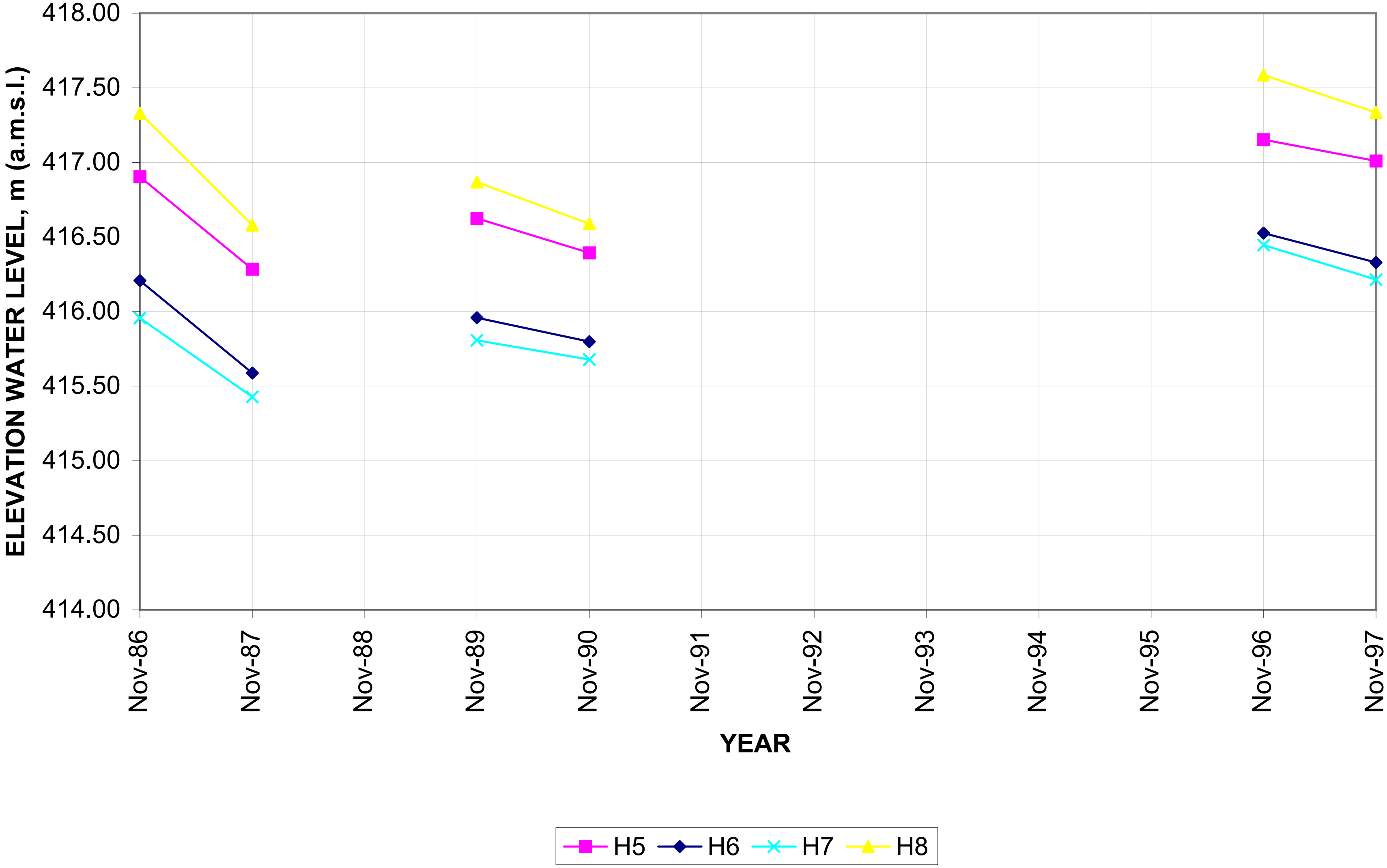


FIGURE 21. ELEVATION OF WATER LEVEL IN PIEZOMETERS H5, H6 & H7 IN OCTOBER AND NOVEMBER OVER PERIOD 1986 - 1997

FIGURE 22. ELEVATION OF WATER LEVEL IN PIEZOMETERS: M7N, M7S, M8, M9, M32, M43, M45, M46 & M47 IN 1987

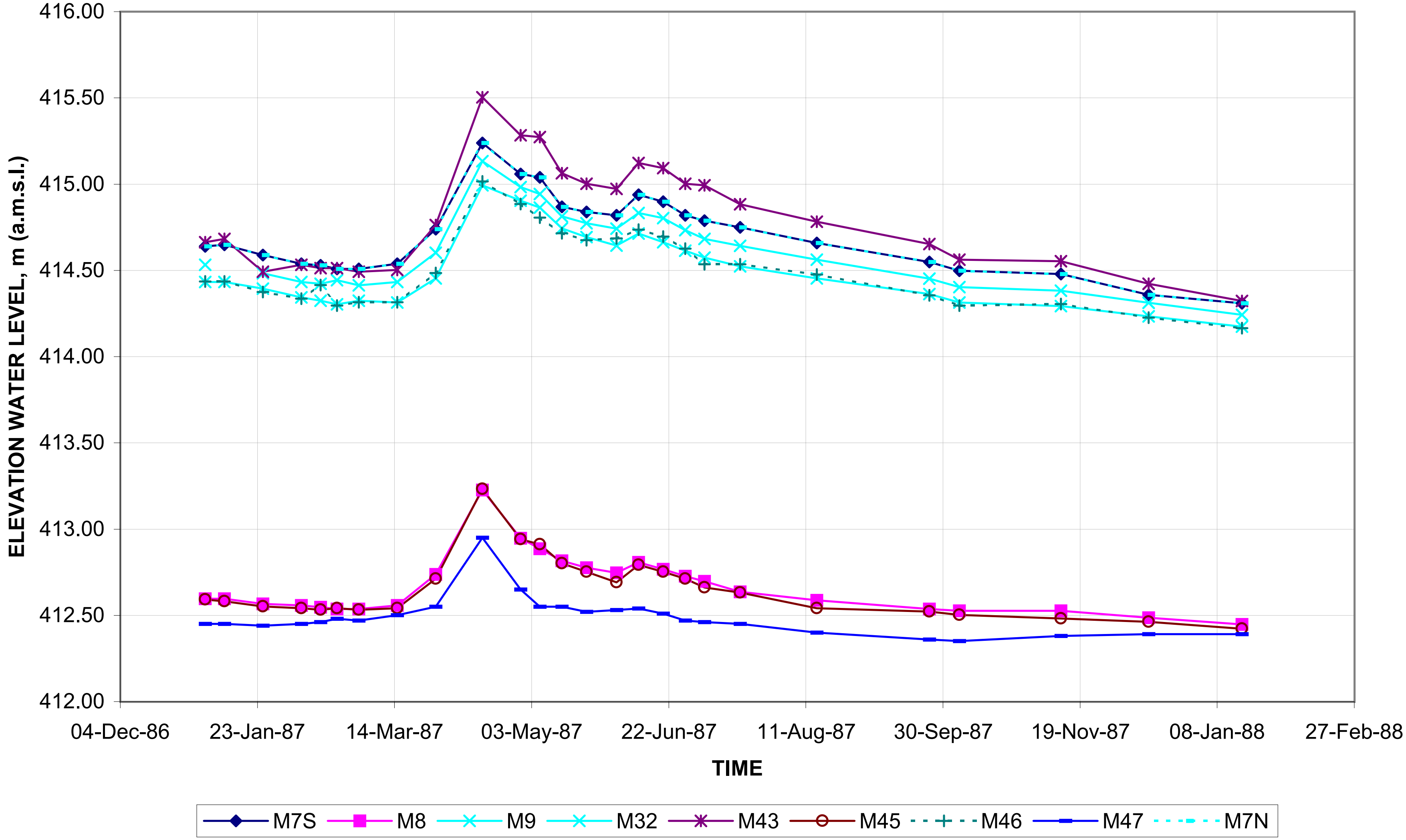


FIGURE 23. ELEVATION OF WATER LEVEL IN PIEZOMETERS: M7N, M7S, M8, M9, M32, M43, M45, M46 & M47 IN 1996-1998

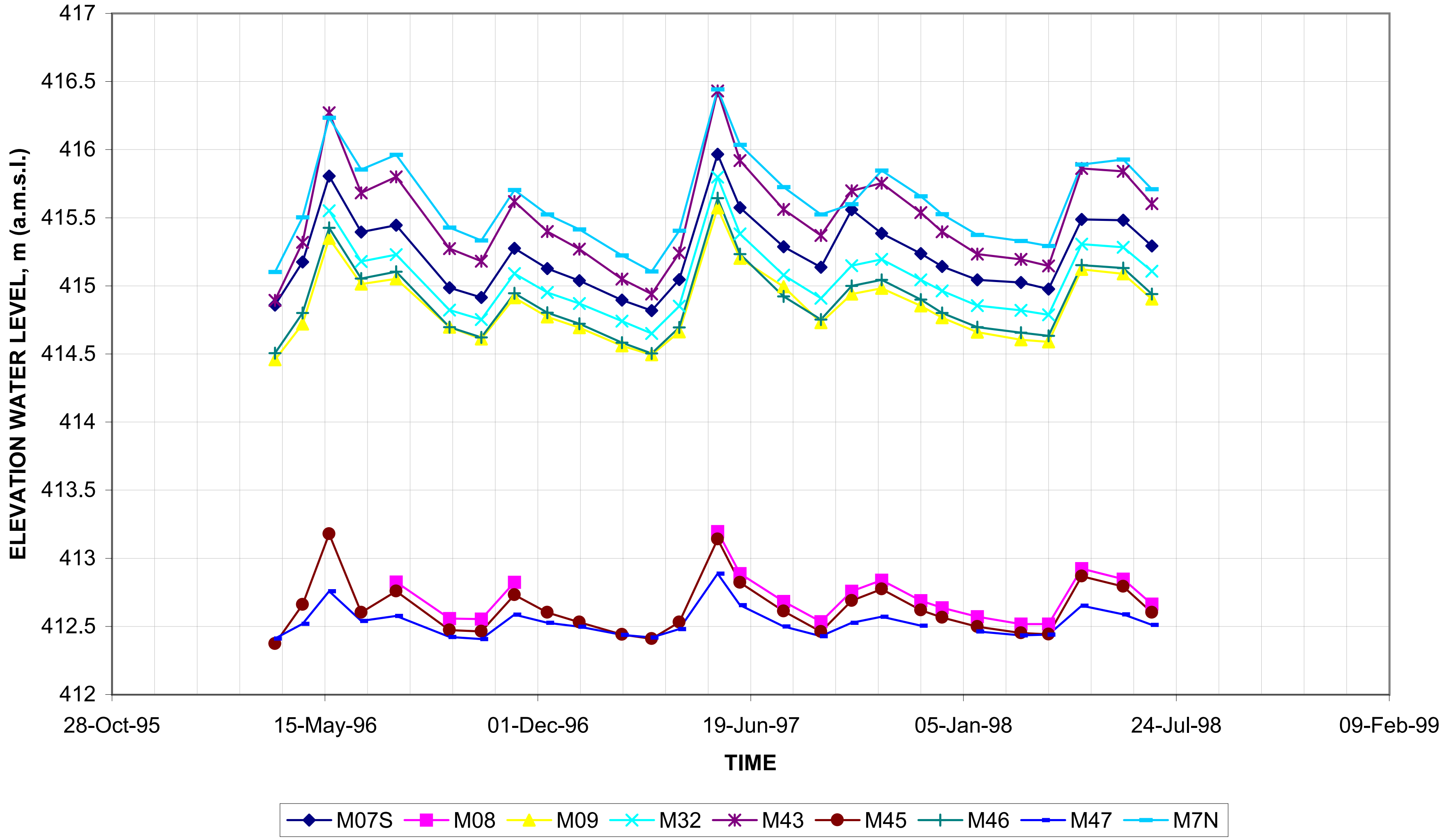


FIGURE 24. ELEVATION OF WATER LEVEL IN PIEZOMETERS M5C, M39A, M79, M80 AND M81 IN 1996-1998