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Development of rainfall-runoff models for the Sieg and Lippe

Final Report, Volume II: Annexes, Tables and Figures

February, 1998

R3049

WL | delft hydraulics

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CLIENT : Rijkswaterstaat RIZA (Arnhem)

TITLE : Final Report, Volume II: Annexes, Tables and Figures

ABSTRACT :

The FLORIJN project concerns the development of rainfall-runoff models fot he rivers Sieg and Lippe in Germany. In this Volume of the Final Report (i.e. Volume II: Annexes, Table and Figures) contains Annexes, Tables and Figures belonging to Volme I: Main Text

REFERENCES:

REV.	ORIGINATOR		DATE	REMARKS	REVIEWED BY		APPROVED BY	
	M. van Mierlo	*(signed)*	19-2-1998		K.V. Heynert	*(signed)*	E. van Beek	*(signed)*

KEYWORD(S)	CONTENTS	STATUS
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	PROJECT IDENTIFICATION: R3049	

CONTENTS

1 Introduction

The FLORIJN project concerns the development of a flood forecasting model for level gauge Lobith. The aim of the FLORIJN project is to be able to forecast high water levels at Lobith three day in advance with sufficient reliability. A part of the FLORIJN model comprises of rainfall-runoff models for the rivers Sieg and Lippe in Germany. RIZA commissioned the development of these two rainfall-runoff models to WL | Delft Hydraulics.

Three earlier reports, concerning the development of the two rainfall-runoff models, were produced, respectively: the First Progress Report in November 1996, the Second Progress Report in July 1997 and the Third Progress Report in November 1997. In accordance with the contract (RIZA-overeenkomst nr. RI-2040), the following subjects are to be reported upon in this Final Report, viz:

1. Data collection,
2. Validation of available hydro-meteorlogical data,
3. Preparation of data-sets with different spatial refinement,
4. Determination of spatial relationships between on-line and off-line stations,
5. System analysis (i.e. characteristics of the Sieg and Lippe catchments),
6. Advice on type of snow-melt module required,
7. Calibration & validation of the rainfall-runoff models, and
8. Sensitivity analysis of the rainfall-runoff models.

The Final Report consists of two Volumes, i.e. Volume I: Main Report and Volume II: Annexes, Tables and Figures. The current report concerns Volume II of the Final Report and contains all Annexes, Tables and Figures refered to in the Main Report.

ANNEXES

Annex I Minutes of meeting with BFG

Project : Rainfall-runoff modelling of the river Sieg & Lippe.
Proj. No. :R3049.00
Concerns : Minutes of the meeting with BfG on January 29th, 1997 in their office in Koblenz.
From : Thieu van Mierlo & Ron Passchier of DELFT HYDRAULICS.

Participants of the meeting were:

- Mr. Sprokkereef of Rijkswaterstaat, RIZA, Arnhem;
- Dr. Wilke (Regierungdirector), BfG
- Mr. Krahe , BfG
- Mr. Daamen , BfG
- Mr. R. Passchier DELFT HYDRAULICS
- Mr. T. van Mierlo DELFT HYDRAULICS

Context and scope of the meeting:

Dr. Wilke welcomed everybody and consequently opened the meeting. He requested Mr. Sprokkereef to elaborate on the purpose of the meeting. After this invitation Mr. Sprokkereef informed the meeting that RIZA, Rijkswaterstaat is developing the FLORIJN instrumentarium. The aim of FLORIJN is to predict high flood-levels on the river Rhine more than two days in advance. Apart from a hydro-dynamic model (based on SOBEK) for the stretch of the river Rhine from Andernach to Lobith, the FLORIJN instrumentarium will comprise of two rainfall-runoff models, respectively for the river Sieg and the river Lippe in Germany. Mr. Sprokkereef mentioned that he had requested Mr. Wilke for the present meeting in order to share the experience of the Bundesanstalt fuer Gewasserkunde (BfG) in modelling the rainfall-runoff process (with emphasis on snow modelling) of tributary rivers in the Rhine basin, and to be informed on relevant data available at BfG. After Mr. Sprokkereef's elaboration, Dr. Wilke suggested to start discussing on the experience of BfG in modelling hydrological processes and thereafter concentrate on availability of relevant data.

Experience of BfG in rainfall-runoff modelling:

The present status of the use of mathematical models by the BfG for predicting high-floods can be summarised as follows. Dr. Steinerbach developed a hydro-dynamic model, which is used to forecast low water levels (i.e. for navigation purposes) on the river Rhine. The input of the model comprises of on-real-time collected water levels (which are converted to discharges) on the river Rhine and on its main tributaries. Rainfall-runoff models are not linked with this hydro-dynamic model. There are plans to apply this hydro-dynamic model in future also for flood forecasting purposes.

At present there are no operational rainfall-runoff models available at BfG for predicting the outflow of tributaries of the river Rhine. Mr. Krahe developed a pilot rainfall-runoff model for a particular area in the northern part of the Moesel catchment. This model, based on the thesis work of Mr. Vehvilaeinen, includes a snow module. Calibration results of the pilot model were, however, not yet available. A copy of the thesis work of Mr. Vehvilaeinen was handed over in the meeting. Other experiences of models by BfG comprises of the application of the NASIM model, which is considered to be too complicated for real-time forecasting purposes. The NASIM model was applied by BfG for the Saar basin. Especially the derivation of the required parameters was cumbersome. Other models, which are considered by the BfG are the SRM, HSPF, Todini and HBV models. The HBV model will be tested soon for flood modelling. The HSPF model is applied for climate change studies, in co-operation with RIZA/Arnhem.

The Deutsche Wetter Dienst (DWD) has developed a physical and raster based (i.e. more complicated than a degree-day model) rainfall-runoff model, entitled SNOW-D, which is presently tested on the Neckar basin. It is anticipated that in future this model will be used for the whole of Germany. The model will be used for real-time forecasting purposes. The model input will be derived from the DWD weather forecast. Results of the SNOW-D model of its application on the Neckar basin were not available.

Relevant data available at BfG:

It was informed that the BfG does not collect hydro-meteorological data, and that streamflow data is collected by the various Staatliches Umweltambten, while meteorological data is collected by the Deutsche Wetter Dienst (DWD). The BfG retrieves meteorological data from the Deutschland Wetter Forecast (DWF) model. The DWF model is owned and operated by the DWD. The DWF model provides information on historical and forecasted (72 hours in advance) precipitation (both rainfall & snow). The information refers to rasters of 14 km by 14 km. At present the minimum time-step is 6 hours. It is anticipated that in future this time step can be reduced to 1 hour. An overview of additional data (e.g. temperatures, etc.) which can be retrieved from the DWF model was handed over in the meeting. Further on it to be mentioned that Mr. Krahe developed a software tool for comparing predictions by the Deutschland Wetter Forecast Model with the actual measured precipitation. The results of these comparisons will be very useful for the anticipated sensitivity analysis of the validated rainfall-runoff models of the river Sieg & Lippe. It was suggested that the best way for collecting the required meteorological data might be through DWD or the Rhine committee.

Actions:

1. It was agreed upon that Eric Sprokkereef will make an appointment with the Deutsche Wetter Dienst for a visit in February/ March 1997.

Annex 2 Data Availability Sieg

1. LUA-NRW meteorological stations (hourly data)

	Flood Period													
Name of station	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Aue	-	-	-	-	-	-	X	X	X	X	X	X	-	-
Bonn Bockeroth	X	X	X	X	X	X	X	X	X	X	X	X	X	-
Bonn-Heizkraftwerk	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Brenzingen	X	X	X	X	X	X	X	X	X	X	X	X	X	-
Eitorf	X	X	X	X	X	X	X	X	X	X	X	X	X	-
Eschmar Muellekoven	X	X	X	X	X	X	X	X	X	X	X	X	X	-
Frielingsdorf	X	X	X	X	X	X	X	X	X	X	X	X	X	-
Haenscheid	X	X	X	X	X	X	X	X	X	X	X	X	X	-
Helgersdorf	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Homburg-Broel	X	X	X	X	X	X	X	X	X	X	X	X	X	-
Kuchenbach	X	X	X	X	X	X	X	X	X	X	X	X	X	-
Lahnhof-Geiersgrund	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Lahnhof-1	-	-	-	-	-	-	-	-	-	-	X	X	-	-
Lehruch (Lehmbach)	X	X	X	X	X	X	X	X	X	X	X	X	X	-
Marienfeld	X	X	X	X	X	X	X	X	X	X	X	X	X	-
Neunkirchen Seelsch.	X	X	X	X	X	X	X	X	X	X	X	X	X	-
Olpe	-	-	-	-	X	X	X	X	X	X	X	X	-	-
Rehringhausen	X	X	X	X	X	X	X	X	X	X	X	-	-	-
Siegen Ghs	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Suelze	X	X	X	X	X	X	X	X	X	X	X	X	-	-

2. DWD synoptic/KL-climatic stations (KL-climatic stations in bold)

	Flood Period													
Name of station	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Bad Marienberg	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bendorf	-	-	-	-	-	-	-	-	X	X	X	X	X	X
Bonn-Friesdorf	X	X	X	X	X	X	X	X	-	-	-	-	-	-
Bonn-Hardthoehe	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Koln-Wahn	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Mendig	-	X	X	X	X	X	X	X	X	X	X	X	X	X
Noervenich	-	X	X	X	X	X	X	X	X	X	X	X	X	X

3. Rated river gauging stations (hourly discharge data)

	Flood Period													
Name of station	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Betzdorf	-	-	-	-	-	-	-	-	-	-	-	X	X	X
Broel	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Eitorf	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Heimborn	X	X	X	X	-	-	-	-	-	-	-	X	X	X
Helgersdorf	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Lahnhof-1	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Lohmar	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Menden	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Niederschelden	-	-	-	-	-	-	-	-	-	-	-	X	X	X
Overath	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Siegburg-Kaldauen	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Weidenau	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Annex 3 Data availability Lippe

1. LUA-NRW meteorological stations (hourly data)

	Flood Period													
Name of station	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Baumberg	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Boenen	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Boke	X	X	X	X	X	X	X	X	X	X	-	-	-	-
Bottrop Eigen	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Brilon 1	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Buke	X	X	X	X	X	X	X	X	X	X	-	-	-	-
Castrop-Rauxel	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Detmold-Zentral KLG.	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Dorsten	X	X	X	X	X	X	X	X	X	X	X	X	-	
Dortmund Kurl	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Dortmund-Aplerbeck	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Dortmund-Marten	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Dortmund-Nettebach	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Effeln	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Herringen	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Kleinenberg	X	X	X	X	X	X	X	-	-	-	-	-	-	-
Lippstad Lipperbr.	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Luedinghausen KLG	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Madfeld	X	X	X	X	X	X	-	X	X	X	X	X	-	-
Niedermarsberg	X	X	X	X	X	X	X	X	X	X	X	-	-	-
Oberhausen-osterfeld	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Olfen-Fuchtelner Muhle	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Ostbueren	X	X	X	X	X	X	X	X	X	X	X	X	X	-
Paderborn PS1	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Rhynern	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Unna	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Waltrop1	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Westerholt	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Wippringsen	X	X	X	X	X	X	X	X	X	X	X	X	-	-

2. LUA-NRW synoptic/KL-climatic data (KL-climatic stations in bold)

	Flood Period													
Name of station	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Bad-Lippspringe	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bad-Salzuflen	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bocholt-Liedern	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Duesseldorf (Flugwewa)	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Essen (WST)	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Guetersloh	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Hopsten	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Kahler-Asten	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Kalkar	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Koeterberg	-	X	X	X	X	X	X	X	X	X	X	X	-	-
Laarbruch	-	X	X	X	X	X	X	X	X	X	X	X	-	-
Luedenscheid	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Munster/Osnabr. (FWW)	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Rheine-Bentlage	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Warburg	-	X	X	-	X	-	X	X	X	X	X	X	-	-

3. Rated river gauging stations (hourly discharge data)

	Flood Period													
Name of station	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Bentfeld	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Haltern	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Kesseler 3	-	-	-	-	-	-	-	-	-	X	X	X	X	-
Leven	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Lippstadt 2	-	-	X	X	X	X	X	X	X	X	X	X	X	-
Luenen	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Menden	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Niederaden	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Niedertudorf	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Nordborchen	X	X	X	X	X	X	X	X	X	X	X	X	-	-
Olfen	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Schermbeck 1	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Westtunnen	X	X	X	X	X	X	X	X	X	X	X	X	X	-

Annex 4 Spatial relationships of KL-climatic stations with Sieg areal rainfall

Sieg total basin

```
Variable                             Mean      Standard
No.  Name                                      Deviation

  1  SIEG TOTAL BASIN           .11150E+01  .22342E+01
  2  Bad-Marienberg             .13257E+01  .27104E+01
  3  Bonn-Friesdorf             .56473E+00  .14579E+01
  4  Koln-Wahn                  .86179E+00  .20411E+01
```

Correlation matrix

	1	2	3	4
1	**1.000**	**0.836**	**0.639**	**0.735**
2	**0.836**	1.000	0.672	0.668
3	**0.639**	0.672	1.000	0.658
4	**0.735**	0.668	0.658	1.000

Stepwise Regression

```
Variables in regression
      Variable       regression  Std. error of
        Number      coefficient   regr. coeff.
             2           .51260         .01548
             4           .35007         .02056
Intercept......          .13379


Variables **not** in regression
      Variable        Tolerance    Part. corr.
        Number            level    coefficient
             3           .46979         .03176

Dependent variable : SIEG TOTAL BASIN
Independent variable      Regression
                          coefficient
Bad-Marienberg              .51260E+00
Koln-Wahn                   .35007E+00

Intercept             :   .13379E+00
```

Agger basin

Variable No.	Name	Mean	Standard Deviation
1	AGGER	.12359E+01	.25915E+01
2	Bad-Marienberg	.13257E+01	.27104E+01
3	Bonn-Friesdorf	.56473E+00	.14579E+01
4	Koln-Wahn	.86179E+00	.20411E+01

Correlation matrix

	1	2	3	4
1	**1.000**	**0.764**	**0.577**	**0.725**
2	**0.764**	1.000	0.672	0.668
3	**0.577**	0.672	1.000	0.658
4	**0.725**	0.668	0.658	1.000

Stepwise Regression

Variables in regression

Variable Number	regression coefficient	Std. error of regr. Coeff.
2	.48287	.02094
4	.49190	.02780
Intercept......	.17187	

Variables **not** in regression

Variable Number	tolerance level	part. Corr. coefficient
3	.46979	-.04416

Dependent variable : AGGER

Independent variable	Regression coefficient
Bad-Marienberg	.48287E+00
Koln-Wahn	.49190E+00

Intercept : .17187E+00

Lower Sieg basin

Variable No.	Name	Mean	Standard Deviation
1	LOWER SIEG BASIN	.68562E+00	.16550E+01
2	Bad-Marienberg	.13257E+01	.27104E+01
3	Bonn-Friesdorf	.56473E+00	.14579E+01
4	Koln-Wahn	.86179E+00	.20411E+01

Correlation matrix

	1	2	3	4
1	**1.000**	**0.720**	**0.763**	**0.719**
2	**0.720**	1.000	0.672	0.668
3	**0.763**	0.672	1.000	0.658
4	**0.719**	0.668	0.658	1.000

Stepwise Regression

```
Variables in regression
      Variable       regression  std. Error of
        Number      coefficient   regr. Coeff.
             2           .16182         .01401
             3           .45803         .02573
             4           .22374         .01831
Intercept......          .01962


Dependent variable : LOWER SIEG BASIN
Independent variable      Regression
                          coefficient
Bad-Marienberg              .16182E+00
Bonn-Friesdorf              .45803E+00
Koln-Wahn                   .22374E+00

Intercept                :    .19619E-01
```

Middle Sieg basin

```
Variable                              Mean     Standard
No.  Name                                     Deviation

  1  MIDDLE SIEG BASIN         .10956E+01  .23135E+01
  2  Bad-Marienberg            .13257E+01  .27104E+01
  3  Bonn-Friesdorf            .56473E+00  .14579E+01
  4  Koln-Wahn                 .86179E+00  .20411E+01
```

Correlation matrix

	1	2	3	4
1	**1.000**	**0.831**	**0.644**	**0.734**
2	**0.831**	1.000	0.672	0.668
3	**0.644**	0.672	1.000	0.658
4	**0.734**	0.668	0.658	1.000

Stepwise Regression

```
Variables in regression
      Variable       regression  std. Error of
        Number      coefficient   regr. Coeff.
             2           .52631         .01624
             4           .36434         .02157
```

```
Intercept......          .08387

Variables **not** in regression
      Variable      tolerance     part. Corr.
        Number          level     coefficient
             3         .46979          .05247


Dependent variable : MIDDLE SIEG BASIN
Independent variable      Regression
                          coefficient
Bad-Marienberg              .52631E+00
Koln-Wahn                   .36434E+00

Intercept              :    .83867E-01
```

Upper Sieg basin

```
Variable                               Mean     Standard
No.  Name                                      Deviation

  1  UPPER SIEG BASIN           .11485E+01  .22983E+01
  2  Bad-Marienberg             .13257E+01  .27104E+01
  3  Bonn-Friesdorf             .56473E+00  .14579E+01
  4  Koln-Wahn                  .86179E+00  .20411E+01
```

Correlation matrix

	1	2	3	4
1	**1.000**	**0.806**	**0.569**	**0.646**
2	**0.806**	1.000	0.672	0.668
3	**0.569**	0.672	1.000	0.658
4	**0.646**	0.668	0.658	1.000

Stepwise Regression

```
Variables in regression
      Variable     regression  std. Error of
        Number    coefficient   regr. Coeff.
             2         .57413         .01847
             4         .21732         .02452
Intercept......        .20014


Variables **not** in regression
      Variable      tolerance     part. Corr.
        Number          level     coefficient
             3         .46979         -.03301


Dependent variable : UPPER SIEG BASIN
Independent variable      Regression
                          coefficient
Bad-Marienberg              .57413E+00
Koln-Wahn                   .21732E+00
```

```
Intercept              :   .20014E+00
```

Middle/Upper Sieg basin

```
Variable                                 Mean      Standard
No.  Name                                          Deviation

  1  UPPER/MIDDLE SIEG               .11291E+01  .22741E+01
  2  Bad-Marienberg                  .13257E+01  .27104E+01
  3  Bonn-Friesdorf                  .56473E+00  .14579E+01
  4  Koln-Wahn                       .86179E+00  .20411E+01
```

Correlation matrix

	1	2	3	4
1	**1.000**	**0.836**	**0.611**	**0.689**
2	**0.836**	1.000	0.672	0.668
3	**0.611**	0.672	1.000	0.658
4	**0.689**	0.668	0.658	1.000

Stepwise Regression

```
Variables in regression
      Variable     regression  std. Error of
        Number    coefficient    regr. Coeff.
             2         .56900          .01656
             4         .26280          .02199
Intercept......        .14829

Variables **not** in regression
      Variable      tolerance    part. Corr.
        Number          level    coefficient
             3         .46979          .00117

Dependent variable : UPPER/MIDDLE SIEG
Independent variable      Regression
                          coefficient
Bad-Marienberg              .56900E+00
Koln-Wahn                   .26280E+00
Intercept              :   .14829E+00
```

Annex 5 Spatial relationships of KL-climatic stations with Lippe areal rainfall

Lippe total basin

Variable No.	Name	Mean	Standard Deviation
1	LIPPE (TOTAL BASIN)	.87130E+00	.19092E+01
2	Bad-Lippspringe	.10384E+01	.25237E+01
3	Bad-Salzuflen	.92170E+00	.22668E+01
4	Bocholt-L.	.78095E+00	.24527E+01
5	Dusseldorf (Fl)	.87090E+00	.21257E+01
6	Essen	.10002E+01	.23989E+01
7	Guetersloh	.85510E+00	.20624E+01
8	Kahler-Asten	.17821E+01	.37103E+01
9	Luedenscheid	.14205E+01	.30188E+01
10	Munster/Osn.	.79895E+00	.20937E+01

Period 1 - 12

Correlation matrix

	1	2	3	4	5	6	7	8	9	10
1	**1.000**	**0.782**	**0.748**	**0.629**	**0.706**	**0.767**	**0.841**	**0.765**	**0.766**	**0.816**
2	**0.782**	1.000	0.797	0.431	0.534	0.620	0.858	0.754	0.681	0.644
3	**0.748**	0.797	1.000	0.411	0.534	0.591	0.825	0.641	0.624	0.676
4	**0.629**	0.431	0.411	1.000	0.613	0.635	0.499	0.502	0.589	0.599
5	**0.706**	0.534	0.534	0.613	1.000	0.902	0.609	0.600	0.744	0.670
6	**0.767**	0.620	0.591	0.635	0.902	1.000	0.686	0.677	0.792	0.730
7	**0.841**	0.858	0.825	0.499	0.609	0.686	1.000	0.716	0.694	0.782
8	**0.765**	0.754	0.641	0.502	0.600	0.677	0.716	1.000	0.835	0.641
9	**0.766**	0.681	0.624	0.589	0.744	0.792	0.694	0.835	1.000	0.677
10	**0.816**	0.644	0.676	0.599	0.670	0.730	0.782	0.641	0.677	1.000

Stepwise Regression

Variables in regression

Variable Number	regression coefficient	std. Error of regr. Coeff.
2	.09883	.01545
3	.06097	.01434
4	.09611	.00957
5	.06560	.01908
6	.05378	.01919
7	.19528	.02137
8	.08362	.00785
10	.22062	.01536
Intercept......	.03424	

```
Variables **not** in regression
      Variable      tolerance    part. Corr.
        Number          level    coefficient
             9         .19769         .03257


Dependent variable : LIPPE (TOTAL BASIN)
Independent variable       Regression
                           coefficient
Bad-Lippspringe              .98834E-01
Bad-Salzuflen                .60974E-01
Bocholt-L.                   .96106E-01
Dusseldorf (Fl)              .65602E-01
Essen                        .53779E-01
Guetersloh                   .19528E+00
Kahler-Asten                 .83619E-01
Munster/Osn.                 .22062E+00

Intercept                :  .34237E-01
```

Lower Lippe basin

```
Variable                                Mean     Standard
No.  Name                                       Deviation

  1  LOWER LIPPE BASIN            .87505E+00  .21481E+01
  2  Bad-Salzuflen                .91825E+00  .22624E+01
  3  Bocholt-L.                   .77740E+00  .24519E+01
  4  Dusseldorf (Fl)              .86975E+00  .21257E+01
  5  Essen                        .99820E+00  .23988E+01
  6  Guetersloh                   .85200E+00  .20590E+01
  7  Kahler-Asten                 .17760E+01  .37095E+01
  8  Luedenscheid                 .14153E+01  .30164E+01
  9  Munster/Osn.                 .79275E+00  .20886E+01
```

Correlation matrix

	1	2	3	4	5	6	7	8	9
1	**1.000**	**0.582**	**0.679**	**0.734**	**0.776**	**0.666**	**0.578**	**0.652**	**0.761**
2	**0.582**	1.000	0.411	0.535	0.591	0.824	0.640	0.623	0.677
3	**0.679**	0.411	1.000	0.613	0.636	0.499	0.501	0.589	0.600
4	**0.734**	0.535	0.613	1.000	0.902	0.609	0.600	0.745	0.672
5	**0.776**	0.591	0.636	0.902	1.000	0.687	0.677	0.792	0.732
6	**0.666**	0.824	0.499	0.609	0.687	1.000	0.716	0.693	0.784
7	**0.578**	0.640	0.501	0.600	0.677	0.716	1.000	0.835	0.642
8	**0.652**	0.623	0.589	0.745	0.792	0.693	0.835	1.000	0.678
9	**0.761**	0.677	0.600	0.672	0.732	0.784	0.642	0.678	1.000

Stepwise Regression

Variables in regression

Variable Number	regression coefficient	std. Error of regr. Coeff.
2	.07069	.01617
3	.20786	.01420
4	.12664	.02812
5	.26698	.02845
8	-.05724	.01494
9	.32905	.02078
Intercept......	.09207	

Variables **not** in regression

Variable Number	tolerance level	part. Corr. coefficient
6	.21229	.04166
7	.27161	-.01515

Dependent variable : LOWER LIPPE BASIN

Independent variable	Regression coefficient
Bad-Salzuflen	.70686E-01
Bocholt-L.	.20786E+00
Dusseldorf (Fl)	.12664E+00
Essen	.26698E+00
Luedenscheid	-.57245E-01
Munster/Osn.	.32905E+00

Intercept : .92065E-01

Middle Lippe basin

Variable No.	Name	Mean	Standard Deviation
1	MIDDLE LIPPE BASIN	.83185E+00	.19455E+01
2	Bad-Lippspringe	.10384E+01	.25237E+01
3	Bad-Salzuflen	.92170E+00	.22668E+01
4	Bocholt-L.	.78095E+00	.24527E+01
5	Dusseldorf (Fl)	.87090E+00	.21257E+01
6	Essen	.10002E+01	.23989E+01
7	Guetersloh	.85510E+00	.20624E+01
8	Kahler-Asten	.17820E+01	.37104E+01
9	Luedenscheid	.14205E+01	.30188E+01
10	Munster/Osn.	.79895E+00	.20937E+01

Correlation matrix

	1	2	3	4	5	6	7	8	9	10
1	**1.000**	**0.761**	**0.734**	**0.590**	**0.682**	**0.745**	**0.824**	**0.747**	**0.762**	**0.787**
2	**0.761**	1.000	0.797	0.431	0.534	0.620	0.858	0.754	0.681	0.644
3	**0.734**	0.797	1.000	0.411	0.534	0.591	0.825	0.641	0.624	0.676
4	**0.590**	0.431	0.411	1.000	0.613	0.635	0.499	0.502	0.589	0.599
5	**0.682**	0.534	0.534	0.613	1.000	0.902	0.609	0.600	0.744	0.670
6	**0.745**	0.620	0.591	0.635	0.902	1.000	0.686	0.677	0.792	0.730
7	**0.824**	0.858	0.825	0.499	0.609	0.686	1.000	0.716	0.694	0.782
8	**0.747**	0.754	0.641	0.502	0.600	0.677	0.716	1.000	0.835	0.641
9	**0.762**	0.681	0.624	0.589	0.744	0.792	0.694	0.835	1.000	0.677
10	**0.787**	0.644	0.676	0.599	0.670	0.730	0.782	0.641	0.677	1.000

Stepwise Regression

Variables in regression

Variable Number	regression coefficient	std. Error of regr. Coeff.
2	.06989	.01778
3	.06997	.01655
4	.06460	.01106
6	.07989	.01563
7	.23258	.02465
8	.05619	.01105
9	.07842	.01467
10	.19385	.01772
Intercept......	-.00086	

Variables **not** in regression

Variable Number	tolerance level	part. Corr. coefficient
5	.17709	.03266

Dependent variable : MIDDLE LIPPE BASIN

Independent variable	Regression coefficient
Bad-Lippspringe	.69888E-01
Bad-Salzuflen	.69974E-01
Bocholt-L.	.64599E-01
Essen	.79887E-01
Guetersloh	.23258E+00
Kahler-Asten	.56194E-01
Luedenscheid	.78421E-01
Munster/Osn.	.19385E+00

Intercept : -.85884E-03

Upper Lippe basin

Variable No.	Name	Mean	Standard Deviation
1	UPPER LIPPE BASIN	.95365E+00	.21556E+01
2	Bad-Lippspringe	.10372E+01	.25230E+01
3	Bad-Salzuflen	.91840E+00	.22624E+01
4	Bocholt-L.	.77780E+00	.24518E+01
5	Dusseldorf (Fl)	.86990E+00	.21257E+01
6	Essen	.99845E+00	.23988E+01
7	Guetersloh	.85255E+00	.20589E+01
8	Kahler-Asten	.17811E+01	.37140E+01
9	Luedenscheid	.14169E+01	.30165E+01
10	Munster/Osn.	.79290E+00	.20886E+01

Correlation matrix

	1	2	3	4	5	6	7	8	9	10
1	**1.000**	**0.858**	**0.747**	**0.472**	**0.580**	**0.643**	**0.819**	**0.776**	**0.704**	**0.669**
2	**0.858**	1.000	0.798	0.430	0.534	0.619	0.858	0.753	0.681	0.646
3	**0.747**	0.798	1.000	0.411	0.534	0.591	0.824	0.639	0.623	0.677
4	**0.472**	0.430	0.411	1.000	0.613	0.635	0.499	0.501	0.589	0.600
5	**0.580**	0.534	0.534	0.613	1.000	0.902	0.609	0.599	0.744	0.672
6	**0.643**	0.619	0.591	0.635	0.902	1.000	0.686	0.676	0.792	0.732
7	**0.819**	0.858	0.824	0.499	0.609	0.686	1.000	0.715	0.693	0.784
8	**0.776**	0.753	0.639	0.501	0.599	0.676	0.715	1.000	0.834	0.641
9	**0.704**	0.681	0.623	0.589	0.744	0.792	0.693	0.834	1.000	0.678
10	**0.669**	0.646	0.677	0.600	0.672	0.732	0.784	0.641	0.678	1.000

Stepwise Regression

Variables in regression

Variable Number	regression coefficient	std. Error of regr. Coeff.
2	.39157	.01853
5	.05949	.01372
7	.22964	.02230
8	.13866	.00967
Intercept......	.05300	

Variables **not** in regression

Variable Number	tolerance level	part. Corr. coefficient
3	.28839	.06784
4	.58814	.02894
6	.14887	-.03170
9	.20881	-.01351
10	.31656	.03348

```
Dependent variable : UPPER LIPPE BASIN
Independent variable      Regression
                          coefficient
Bad-Lippspringe             .39157E+00
Dusseldorf (Fl)             .59493E-01
Guetersloh                  .22964E+00
Kahler-Asten                .13866E+00

Intercept               :   .52995E-01
```

Stever basin

```
Variable                                  Mean     Standard
No.  Name                                          Deviation

  1  STEVER BASIN                     .81680E+00  .20149E+01
  2  Bad-Salzuflen                    .91825E+00  .22624E+01
  3  Bocholt-L.                       .77740E+00  .24519E+01
  4  Dusseldorf (Fl)                  .86975E+00  .21257E+01
  5  Essen                            .99820E+00  .23988E+01
  6  Guetersloh                       .85200E+00  .20590E+01
  7  Kahler-Asten                     .17760E+01  .37095E+01
  8  Luedenscheid                     .14153E+01  .30164E+01
  9  Munster/Osn.                     .79275E+00  .20886E+01
```

Correlation matrix

	1	2	3	4	5	6	7	8	9
1	**1.000**	**0.624**	**0.684**	**0.677**	**0.724**	**0.729**	**0.640**	**0.683**	**0.852**
2	**0.624**	1.000	0.411	0.535	0.591	0.824	0.640	0.623	0.677
3	**0.684**	0.411	1.000	0.613	0.636	0.499	0.501	0.589	0.600
4	**0.677**	0.535	0.613	1.000	0.902	0.609	0.600	0.745	0.672
5	**0.724**	0.591	0.636	0.902	1.000	0.687	0.677	0.792	0.732
6	**0.729**	0.824	0.499	0.609	0.687	1.000	0.716	0.693	0.784
7	**0.640**	0.640	0.501	0.600	0.677	0.716	1.000	0.835	0.642
8	**0.683**	0.623	0.589	0.745	0.792	0.693	0.835	1.000	0.678
9	**0.852**	0.677	0.600	0.672	0.732	0.784	0.642	0.678	1.000

Stepwise Regression

```
Variables in regression
      Variable      regression   std. Error of
        Number     coefficient     regr. Coeff.
             3          .19070           .01147
             4          .06623           .01471
             6          .09047           .01834
             7          .03185           .00853
             9          .53647           .01819
Intercept......         .05200
```

Variables **not** in regression

Variable Number	tolerance level	part. Corr. coefficient
2	.31245	.00506
5	.14180	.01949
8	.20449	.01735

Dependent variable : STEVER BASIN

Independent variable	Regression coefficient
Bocholt-L.	.19070E+00
Dusseldorf (Fl)	.66233E-01
Guetersloh	.90475E-01
Kahler-Asten	.31855E-01
Munster/Osn.	.53647E+00
Intercept :	.52002E-01

Tables of Chapter 10

Sieg Level 1, Period no. 5, Results of fmin *sensitivity analysis:*

	Prediction in hours in advance	*Mean Absolute Efficiency*	*Maximum Local Efficiency*	*Minimum Local Efficiency*
fmin = 0.1	6	8.6%	31.3%	-54.9%
	12	14.7%	29.1%	-54.8%
	18	16.0%	39.0%	-63.5%
	24	16.7%	55.6%	-79.5%
	30	22.0%	70.5%	-84.1%
	36	27.5%	83.0%	-88.6%
	42	29.7%	93.4%	-95.8%
	48	31.0%	102.1%	-105.9%
fmin = 0.2	6	8.1%	31.3%	-28.6%
	12	13.7%	29.1%	-38.2%
	18	14.7%	29.2%	-40.8%
	24	14.7%	41.0%	-50.4%
	30	19.6%	50.3%	-55.0%
	36	24.6%	57.1%	-59.5%
	42	26.4%	64.4%	-66.7%
	48	27.4%	69.7%	-76.9%
fmin = 0.3 (calibration value)	6	7.8%	31.3%	-28.6%
	12	13.1%	29.1%	-38.2%
	18	14.0%	26.6%	-40.8%
	24	13.7%	25.8%	-37.0%
	30	18.2%	31.4%	-45.1%
	36	22.9%	35.8%	-52.2%
	42	24.4%	38.8%	-58.4%
	48	25.0%	43.8%	-65.2%
fmin = 0.4	6	7.7%	31.3%	-28.6%
	12	12.8%	29.1%	-38.2%
	18	13.6%	26.6%	-40.8%
	24	13.3%	17.2%	-38.5%
	30	17.9%	26.2%	-45.3%
	36	22.6%	24.3%	-52.6%
	42	24.0%	26.0%	-59.0%
	48	24.6%	27.2%	-66.2%

Table 10.1a Sieg Level 1, Period no. 5, Results of sensitivity for the minimum infirltration capacity $f_{min.}$

Sieg Level 1, Period no. 5, Results of fmin *sensitivity analysis:*

	Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
fmin = 0.5	6	7.7%	31.3%	-28.6%
	12	13.1%	29.1%	-38.2%
	18	13.9%	26.6%	-40.8%
	24	13.7%	18.6%	-42.8%
	30	18.4%	26.2%	-45.5%
	36	23.3%	24.3%	-53.0%
	42	24.9%	21.9%	-59.6%
	48	25.9%	15.5%	-67.1%

Model parameters:				
fmin	0.10, 0.20, 0.30		alfa (1,1)	0.29
	0.40 or 0.50		alfa (1,2)	0.14
fmax	5.00		alfa (1,3)	0.10
kb	8.60		alfa (1,4)	0.00
psi	0.93		alfa (1,5)	0.00
kn	10.50		alfa (1,6)	0.00
nn	2.95		alfa (1,7)	0.00
			alfa (1.8)	0.00

Table 10.1b Sieg Level 1, Period no. 5, Results of sensitivity for the minimum infirltration capacity $f_{min.}$

Sieg Level 1, Period no. 12, Results of **fmin** *sensitivity analysis:*

	Prediction in hours in advance	*Mean Absolute Efficiency*	*Maximum Local Efficiency*	*Minimum Local Efficiency*
fmin = 0.1	6	8.8%	28.7%	-122.8%
	12	18.0%	64.7%	-221.1%
	18	24.8%	93.5%	-254.5%
	24	30.9%	111.0%	-254.5%
	30	36.2%	136.7%	-258.1%
	36	41.2%	156.0%	-261.3%
	42	45.5%	170.3%	-263.5%
	48	49.4%	184.7%	-260.9%
fmin = 0.2	6	6.1%	18.0%	-32.4%
	12	11.1%	39.2%	-69.1%
	18	14.6%	58.2%	-87.3%
	24	17.8%	78.3%	-93.4%
	30	21.3%	95.8%	-97.6%
	36	24.6%	109.8%	-100.3%
	42	27.7%	120.0%	-100.0%
	48	30.3%	128.8%	-96.4%
fmin = 0.3 (calibration value)	6	5.3%	18.0%	-28.9%
	12	10.2%	32.3%	-56.9%
	18	14.6%	42.0%	-69.8%
	24	18.9%	46.9%	-72.1%
	30	22.7%	56.5%	-73.8%
	36	26.5%	65.3%	-74.1%
	42	30.3%	77.6%	-73.1%
	48	33.5%	90.4%	-72.7%
fmin = 0.4	6	5.0%	23.0%	-27.5%
	12	8.6%	32.3%	-44.9%
	18	10.9%	42.0%	-49.8%
	24	13.2%	46.1%	-50.9%
	30	15.9%	53.7%	-48.4%
	36	18.6%	56.0%	-45.5%
	42	21.0%	56.0%	-54.0%
	48	23.0%	64.8%	-61.0%

Table 10.2a Sieg Level 1, Period no. 12, Results of sensitivity for the minimum infirltration capacity $f_{min.}$

Sieg Level 1, Period no. 12, Results of fmin *sensitivity analysis:*

	Prediction in hours in advance	*Mean Absolute Efficiency*	*Maximum Local Efficiency*	*Minimum Local Efficiency*
fmin = 0.5	6	4.8%	29.5%	-27.5%
	12	8.2%	35.3%	-26.2%
	18	10.4%	42.0%	-33.6%
	24	12.5%	46.1%	-31.4%
	30	15.2%	53.7%	-38.9%
	36	18.0%	56.0%	-45.5%
	42	20.4%	56.0%	-54.0%
	48	22.3%	54.7%	-61.0%

Model parameters:				
fmin	0.10, 0.20, 0.30		alfa (1,1)	0.29
	0.40 or 0.50		alfa (1,2)	0.14
fmax	5.00		alfa (1,3)	0.10
kb	8.60		alfa (1,4)	0.00
psi	0.93		alfa (1,5)	0.00
kn	10.50		alfa (1,6)	0.00
nn	2.95		alfa (1,7)	0.00
			alfa (1.8)	0.00

Table 10.2b Sieg Level 1, Period no. 12, Results of sensitivity for the minimum infirltration capacity $f_{min.}$

Lippe Level 1, Period no. 7, Results of fmin *sensitivity analysis:*

	Prediction in hours in advance	*Mean Absolute Efficiency*	*Maximum Local Efficiency*	*Minimum Local Efficiency*
fmin = 0.01	6	3.5%	50.7%	-93.7%
	12	7.1%	42.0%	-98.0%
	18	10.5%	21.6%	-111.9%
	24	13.2%	26.0%	-120.0%
	30	15.3%	28.6%	-118.9%
	36	17.0%	30.6%	-115.7%
	42	18.7%	31.0%	-112.0%
	48	20.5%	35.1%	-109.5%
	54	22.4%	41.6%	-106.2%
	60	24.3%	47.1%	-111.6%
fmin = 0.1	6	2.8%	11.7%	-19.2%
	12	5.6%	18.0%	-27.3%
	18	8.0%	20.5%	-33.0%
	24	9.6%	24.2%	-35.5%
	30	10.6%	26.3%	-42.9%
	36	11.7%	28.0%	-43.5%
	42	12.9%	32.0%	-48.7%
	48	14.0%	35.5%	-55.8%
	54	15.2%	38.4%	-59.1%
	60	16.6%	41.0%	-68.4%
fmin = 0.2 (calibration value)	6	2.8%	11.7%	-19.2%
	12	5.7%	21.3%	-27.3%
	18	8.3%	32.3%	-33.9%
	24	10.1%	39.1%	-38.1%
	30	11.4%	44.2%	-47.3%
	36	12.7%	46.6%	-48.9%
	42	14.2%	47.4%	-54.7%
	48	15.7%	49.6%	-62.7%
	54	17.4%	51.8%	-66.7%
	60	19.4%	53.8%	-76.8%
fmin = 0.3	6	2.8%	11.7%	-19.2%
	12	5.9%	21.5%	-27.3%
	18	8.9%	32.9%	-33.9%
	24	10.9%	39.6%	-38.1%
	30	12.5%	44.9%	-47.3%
	36	14.0%	47.5%	-48.9%
	42	15.6%	48.7%	-54.7%
	48	17.2%	50.6%	-62.7%
	54	18.9%	52.5%	-66.7%
	60	20.9%	54.8%	-76.8%

Table 10.3a Lippe Level 1, Period no. 7, Results of sensitivity for the minimum infirltration capacity $f_{min.}$

Lippe Level 1, Period no. 7, Results of fmin *sensitivity analysis:*

	Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
fmin = 0.4	6	2.9%	11.7%	-19.2%
	12	6.6%	21.5%	-27.3%
	18	10.2%	32.9%	-33.9%
	24	12.6%	39.6%	-38.1%
	30	14.5%	44.9%	-47.3%
	36	16.3%	47.5%	-48.9%
	42	18.1%	50.2%	-54.7%
	48	19.9%	51.2%	-62.7%
	54	21.8%	56.5%	-66.7%
	60	23.7%	60.5%	-76.8%

Model parameters:				
fmin	0.10, 0.20, 0.30		alfa (1,1)	0.52
	0.40 or 0.50		alfa (1,2)	0.41
fmax	5.00		alfa (1,3)	0.00
kb	3.37		alfa (1,4)	0.00
psi	0.80		alfa (1,5)	0.00
kn	32.60		alfa (1,6)	0.00
nn	2.41		alfa (1,7)	0.00
			alfa (1.8)	0.00
			alfa (1,9)	0.00
			alfa (1.10)	0.00

Table 10.3b Lippe Level 1, Period no. 7, Results of sensitivity for the minimum infirltration capacity $f_{min.}$

Lippe Level 1, Period no. 9, Results of fmin *sensitivity analysis:*

	Prediction in hours in advance	*Mean Absolute Efficiency*	*Maximum Local Efficiency*	*Minimum Local Efficiency*
fmin = 0.01	6	4.2%	14.0%	-18.0%
	12	9.2%	26.7%	-48.0%
	18	13.6%	36.1%	-80.7%
	24	16.3%	41.6%	-98.3%
	30	18.9%	50.5%	-110.9%
	36	21.5%	60.1%	-124.6%
	42	23.8%	71.3%	-135.0%
	48	26.1%	80.6%	-134.7%
	54	28.5%	89.4%	-141.9%
	60	30.9%	97.7%	-141.6%
fmin = 0.1	6	3.9%	15.2%	-15.6%
	12	7.7%	33.9%	-30.3%
	18	10.3%	48.7%	-40.2%
	24	12.0%	52.9%	-46.8%
	30	13.6%	56.0%	-54.5%
	36	14.9%	54.3%	-61.5%
	42	15.8%	51.1%	-69.5%
	48	17.1%	55.7%	-74.7%
	54	18.5%	58.6%	-75.2%
	60	20.0%	60.7%	-68.6%
fmin = 0.2 (calibration value)	6	3.8%	15.2%	-14.1%
	12	7.3%	33.9%	-33.3%
	18	9.7%	48.7%	-37.7%
	24	11.2%	52.9%	-37.7%
	30	12.6%	56.0%	-32.3%
	36	13.8%	54.3%	-35.4%
	42	14.9%	51.1%	-38.8%
	48	16.1%	55.7%	-40.1%
	54	17.4%	58.6%	-43.8%
	60	18.5%	60.7%	-49.6%
fmin = 0.3	6	3.9%	15.2%	-14.1%
	12	7.9%	33.9%	-33.3%
	18	11.1%	48.7%	-37.7%
	24	13.1%	52.9%	-37.7%
	30	15.2%	57.3%	-32.3%
	36	17.0%	59.6%	-35.4%
	42	18.6%	60.1%	-38.8%
	48	20.3%	61.2%	-42.4%
	54	21.9%	62.2%	-49.8%
	60	23.4%	64.2%	-57.6%

Table 10.4a Lippe Level 1, Period no. 9, Results of sensitivity for the minimum infirltration capacity $f_{min.}$

Lippe Level 1, Period no. 9, Results of fmin *sensitivity analysis:*

	Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
fmin = 0.4	6	3.9%	15.9%	-14.1%
	12	8.2%	33.9%	-33.3%
	18	11.8%	48.7%	-37.7%
	24	14.1%	56.9%	-37.7%
	30	16.4%	62.5%	-33.0%
	36	18.5%	66.4%	-36.1%
	42	20.4%	68.1%	-40.1%
	48	22.3%	69.6%	-49.5%
	54	24.2%	70.8%	-58.4%
	60	26.0%	72.9%	-66.7%

Model parameters:				
fmin	0.10, 0.20, 0.30		alfa (1,1)	0.52
	0.40 or 0.50		alfa (1,2)	0.41
fmax	5.00		alfa (1,3)	0.00
kb	3.37		alfa (1,4)	0.00
psi	0.80		alfa (1,5)	0.00
kn	32.60		alfa (1,6)	0.00
nn	2.41		alfa (1,7)	0.00
			alfa (1.8)	0.00
			alfa (1,9)	0.00
			alfa (1.10)	0.00

Table 10.4b Lippe Level 1, Period no. 9, Results of sensitivity for the minimum infirltration capacity f_{min}

Sieg Level 1, Period no. 5, Rainfall sensitivity analysis:

	Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
Calibration:	6	7.8%	31.3%	-28.6%
	12	13.1%	29.1%	-38.2%
	18	14.0%	26.6%	-40.8%
	24	13.7%	25.8%	-37.0%
	30	18.2%	31.4%	-45.1%
	36	22.9%	35.8%	-52.2%
	42	24.4%	38.8%	-58.4%
	48	25.0%	43.8%	-65.2%
Overestimation of rainfall:	6	11.5%	31.3%	-37.1%
+ 20% for 0 < t < 24 hours	12	16.0%	29.1%	-52.1%
+ 40% for 24 < t < 48 hours	18	16.0%	26.6%	-59.5%
	24	15.8%	11.6%	-60.1%
	30	24.5%	26.2%	-89.5%
	36	29.3%	24.3%	-90.1%
	42	31.2%	21.9%	-90.3%
	48	32.3%	24.8%	-98.6%
Underestimation of rainfall:	6	10.4%	36.2%	-28.6%
- 20% for 0 < t < 24 hours	12	14.9%	35.5%	-38.2%
- 40% for 24 < t < 48 hours	18	14.9%	37.4%	-40.8%
	24	14.4%	40.4%	-37.0%
	30	21.5%	62.1%	-45.0%
	36	25.9%	62.2%	-52.2%
	42	26.9%	62.3%	-58.3%
	48	27.0%	61.5%	-65.1%

Model parameters:				
fmin	0.30		alfa (1,1)	0.29
fmax	5.00		alfa (1,2)	0.14
kb	8.60		alfa (1,3)	0.10
psi	0.93		alfa (1,4)	0.00
kn	10.50		alfa (1,5)	0.00
nn	2.95		alfa (1,6)	0.00
			alfa (1,7)	0.00
			alfa (1.8)	0.00

Table 10.5 Sieg Level 1: Results of rainfall sensitivity analysis for Period no. 5

Sieg Level 1, Period no. 12, Rainfall sensitivity analysis:

	Prediction in hours in advance	*Mean Absolute Efficiency*	*Maximum Local Efficiency*	*Minimum Local Efficiency*
Validation:	6	5.0%	23.0%	-27.5%
	12	8.6%	32.3%	-44.9%
	18	10.9%	42.0%	-49.8%
	24	13.2%	46.1%	-50.9%
	30	15.9%	53.7%	-48.4%
	36	18.6%	56.0%	-45.5%
	42	21.0%	56.0%	-54.0%
	48	23.0%	64.8%	-61.0%
Overestimation of rainfall:	6	9.6%	18.0%	-80.1%
+ 20% for 0 < t < 24 hours	12	12.1%	32.3%	-99.5%
+ 40% for 24 < t < 48 hours	18	13.6%	42.0%	-104.3%
	24	15.1%	46.1%	-105.4%
	30	23.2%	50.2%	-150.1%
	36	25.3%	52.9%	-143.0%
	42	27.2%	52.9%	-142.0%
	48	28.6%	52.5%	-141.6%
Underestimation of rainfall:	6	9.9%	75.7%	-27.5%
- 20% for 0 < t < 24 hours	12	12.8%	73.2%	-26.2%
- 40% for 24 < t < 48 hours	18	14.7%	71.7%	-33.6%
	24	16.6%	71.1%	-31.4%
	30	23.2%	101.8%	-38.9%
	36	25.8%	101.7%	-45.5%
	42	28.2%	101.8%	-54.0%
	48	30.3%	102.0%	-61.0%

Model parameters:				
fmin	0.40		alfa (1,1)	0.29
fmax	5.00		alfa (1,2)	0.14
kb	8.60		alfa (1,3)	0.10
psi	0.93		alfa (1,4)	0.00
kn	10.50		alfa (1,5)	0.00
nn	2.95		alfa (1,6)	0.00
			alfa (1,7)	0.00
			alfa (1.8)	0.00

Table 10.6 Sieg Level 1: Results of rainfall sensitivity analysis for Period no. 12

Lippe, Level 1, Period no. 7, Rainfall sensitivity analysis:

	Prediction in hours in advance	*Mean Absolute Efficiency*	*Maximum Local Efficiency*	*Minimum Local Efficiency*
Calibration:	6	2.8%	11.7%	-19.2%
	12	5.7%	21.3%	-27.3%
	18	8.3%	32.3%	-33.9%
	24	10.1%	39.1%	-38.1%
	30	11.4%	44.2%	-47.3%
	36	12.7%	46.6%	-48.9%
	42	14.2%	47.4%	-54.7%
	48	15.7%	49.6%	-62.7%
	54	17.4%	51.8%	-66.7%
	60	19.4%	53.8%	-76.8%
Overestimation of rainfall:	6	7.5%	11.7%	-29.7%
+ 20% for 0 < t < 24 hours	12	9.9%	20.6%	-34.4%
+ 40% for 24 < t < 48 hours	18	12.1%	29.3%	-38.7%
+ 60% for 48 < t < 60 hours	24	13.5%	36.1%	-42.2%
	30	20.4%	36.8%	-70.9%
	36	21.3%	37.4%	-70.9%
	42	22.3%	40.0%	-70.4%
	48	23.5%	41.4%	-72.1%
	54	31.4%	34.3%	-103.2%
	60	32.7%	33.3%	-103.4%
Underestimation of rainfall:	6	7.3%	28.3%	-19.2%
- 20% for 0 < t < 24 hours	12	9.9%	30.8%	-27.3%
- 40% for 24 < t < 48 hours	18	12.2%	37.7%	-33.9%
- 60% for 48 < t < 60 hours	24	13.7%	40.8%	-38.1%
	30	20.0%	59.1%	-47.3%
	36	21.2%	60.8%	-48.9%
	42	22.5%	63.0%	-54.7%
	48	23.9%	65.0%	-62.7%
	54	29.4%	76.3%	-66.7%
	60	31.2%	76.9%	-76.8%

Model parameters:				
fmin	0.20		alfa (1,1)	0.52
fmax	5.00		alfa (1,2)	0.41
kb	3.37		alfa (1,3)	0.00
psi	0.80		alfa (1,4)	0.00
kn	32.60		alfa (1,5)	0.00
nn	2.41		alfa (1,6)	0.00
			alfa (1,7)	0.00
			alfa (1.8)	0.00
			alfa (1.9)	0.00
			alfa (1.10)	0.00

Table 10.7 Lippe Level 1: Results of rainfall sensitivity analysis for Period no. 7

Lippe, Level 1, Period no. 9, Rainfall sensitivity analysis:

	Prediction in hours in advance	*Mean Absolute Efficiency*	*Maximum Local Efficiency*	*Minimum Local Efficiency*
Calibration:	6	3.8%	15.2%	-14.1%
	12	7.3%	33.9%	-33.3%
	18	9.7%	48.7%	-37.7%
	24	11.2%	52.9%	-37.7%
	30	12.6%	56.0%	-32.3%
	36	13.8%	54.3%	-35.4%
	42	14.9%	51.1%	-38.8%
	48	16.1%	55.7%	-40.1%
	54	17.4%	58.6%	-43.8%
	60	18.5%	60.7%	-49.6%
Overestimation of rainfall:	6	11.0%	15.2%	-33.5%
+ 20% for 0 < t < 24 hours	12	12.8%	33.9%	-42.1%
+ 40% for 24 < t < 48 hours	18	13.9%	48.7%	-51.7%
+ 60% for 48 < t < 60 hours	24	14.9%	52.9%	-57.1%
	30	25.2%	56.0%	-105.0%
	36	25.4%	54.3%	-106.5%
	42	25.5%	51.1%	-105.7%
	48	25.9%	55.7%	-107.3%
	54	37.8%	58.6%	-143.3%
	60	38.1%	60.7%	-133.3%
Underestimation of rainfall:	6	11.0%	33.7%	-14.1%
- 20% for 0 < t < 24 hours	12	12.8%	33.9%	-33.3%
- 40% for 24 < t < 48 hours	18	15.5%	48.7%	-37.7%
- 60% for 48 < t < 60 hours	24	16.7%	52.9%	-37.7%
	30	23.1%	62.1%	-32.3%
	36	24.0%	65.9%	-35.4%
	42	24.8%	67.4%	-38.8%
	48	25.8%	68.8%	-40.1%
	54	30.7%	72.9%	-43.8%
	60	31.6%	74.4%	-49.6%

Model parameters:				
fmin	0.20		alfa (1,1)	0.52
fmax	5.00		alfa (1,2)	0.41
kb	3.37		alfa (1,3)	0.00
psi	0.80		alfa (1,4)	0.00
kn	32.60		alfa (1,5)	0.00
nn	2.41		alfa (1,6)	0.00
			alfa (1,7)	0.00
			alfa (1.8)	0.00
			alfa (1.9)	0.00
			alfa (1.10)	0.00

Table 10.8 Lippe Level 1: Results of rainfall sensitivity analysis for Period no. 9

Sieg Level 1, Period no. 5, Differences due to areal rainfall according to LUA-NRW (fmin=0.30) data and DWD (fmin=0.30) data

	Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
Areal rainfall according to rainfall observed at **LUA-NRW** stations (**fmin=0.30**).	6	7.8%	31.3%	-28.6%
	12	13.1%	29.1%	-38.2%
	18	14.0%	26.6%	-40.8%
	24	13.7%	25.8%	-37.0%
	30	18.2%	31.4%	-45.1%
	36	22.9%	35.8%	-52.2%
	42	24.4%	38.8%	-58.4%
	48	25.0%	43.8%	-65.2%
Areal rainfall according to rainfall observed at **DWD** stations & relations between rainfall at DWD stations and areal rainfall according to LUA-NRW stations (**fmin=0.30**)	6	8.6%	31.3%	-28.6%
	12	15.1%	37.3%	-39.7%
	18	16.9%	57.0%	-63.2%
	24	18.0%	77.3%	-77.3%
	30	23.7%	94.5%	-86.2%
	36	29.4%	109.4%	-98.7%
	42	31.8%	121.9%	-122.9%
	48	33.8%	134.2%	-143.2%

Model parameters:				
fmin	0.30		alfa (1,1)	0.29
fmax	5.00		alfa (1,2)	0.14
kb	8.60		alfa (1,3)	0.10
psi	0.93		alfa (1,4)	0.00
kn	10.50		alfa (1,5)	0.00
nn	2.95		alfa (1,6)	0.00
			alfa (1,7)	0.00
			alfa (1.8)	0.00

Table 10.9 Sieg Level 1, Period no. 5, Sensitivity to LUA-NRW and DWD areal rainfall, in both computations **fmin=0.30** was used.

Sieg Level 1, Period no. 5, Differences due to areal rainfall according to LUA-NRW (fmin=0.30) data and DWD (fmin=0.10) data

	Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
Areal rainfall according to rainfall observed at **LUA-NRW** stations (**fmin=0.30**).	6	7.8%	31.3%	-28.6%
	12	13.1%	29.1%	-38.2%
	18	14.0%	26.6%	-40.8%
	24	13.7%	25.8%	-37.0%
	30	18.2%	31.4%	-45.1%
	36	22.9%	35.8%	-52.2%
	42	24.4%	38.8%	-58.4%
	48	25.0%	43.8%	-65.2%
Areal rainfall according to rainfall observed at **DWD** stations & relations between rainfall at DWD stations and areal rainfall according to LUA-NRW stations (**fmin=0.10**)	6	9.3%	31.3%	-47.0%
	12	16.7%	54.2%	-51.0%
	18	19.4%	82.8%	-61.3%
	24	21.7%	113.0%	-76.4%
	30	28.3%	141.1%	-82.8%
	36	34.9%	165.8%	-95.5%
	42	38.2%	187.2%	-120.3%
	48	41.2%	206.1%	-142.1%

Model parameters:				
fmin	0.10 or 0.30		alfa (1,1)	0.29
fmax	5.00		alfa (1,2)	0.14
kb	8.60		alfa (1,3)	0.10
psi	0.93		alfa (1,4)	0.00
kn	10.50		alfa (1,5)	0.00
nn	2.95		alfa (1,6)	0.00
			alfa (1,7)	0.00
			alfa (1.8)	0.00

Table 10.10 Sieg Level 1, Period no. 5, Sensitivity to LUA-NRW and DWD areal rainfall, **fmin=0.30** for LUA-NRW & **fmin = 0.10** for DWD.

Sieg Level 1, Period no. 5, Differences due to areal rainfall according to LUA-NRW (fmin=0.30) data and DWD (fmin=0.50) data

	Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
Areal rainfall according to rainfall observed at **LUA-NRW** stations (**fmin=0.30**).	6	7.8%	31.3%	-28.6%
	12	13.1%	29.1%	-38.2%
	18	14.0%	26.6%	-40.8%
	24	13.7%	25.8%	-37.0%
	30	18.2%	31.4%	-45.1%
	36	22.9%	35.8%	-52.2%
	42	24.4%	38.8%	-58.4%
	48	25.0%	43.8%	-65.2%
Areal rainfall according to rainfall observed at **DWD** stations & relations between rainfall at DWD stations and areal rainfall according to LUA-NRW stations (**fmin=0.50**)	6	8.1%	31.3%	-28.6%
	12	14.1%	29.1%	-44.8%
	18	15.2%	33.1%	-68.1%
	24	15.6%	38.3%	-79.3%
	30	21.0%	43.7%	-91.2%
	36	26.0%	49.6%	-103.2%
	42	27.6%	54.7%	-125.5%
	48	28.7%	58.0%	-141.8%

Model parameters:				
fmin	0.30 or 0.50		alfa (1,1)	0.29
fmax	5.00		alfa (1,2)	0.14
kb	8.60		alfa (1,3)	0.10
psi	0.93		alfa (1,4)	0.00
kn	10.50		alfa (1,5)	0.00
nn	2.95		alfa (1,6)	0.00
			alfa (1,7)	0.00
			alfa (1.8)	0.00

Table 10.11 Sieg Level 1, Period no. 5, Sensitivity to LUA-NRW and DWD areal rainfall, **fmin=0.30** for LUA-NRW & **fmin = 0.50** for DWD.

Sieg Level 1, Period no. 12, Differences due to areal rainfall according to LUA-NRW (fmin=0.40) data and DWD (fmin=0.40) data

	Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
Areal rainfall according to rainfall observed at **LUA-NRW** stations (**fmin=0.40**).	6	5.0%	23.0%	-27.5%
	12	8.6%	32.3%	-44.9%
	18	10.9%	42.0%	-49.8%
	24	13.2%	46.1%	-50.9%
	30	15.9%	53.7%	-48.4%
	36	18.6%	56.0%	-45.5%
	42	21.0%	56.0%	-54.0%
	48	23.0%	64.8%	-61.0%
Areal rainfall according to rainfall observed at **DWD** stations & relations between rainfall at DWD stations and areal rainfall according to LUA-NRW stations (**fmin=0.40**)	6	5.2%	29.5%	-29.1%
	12	9.4%	45.1%	-26.2%
	18	12.2%	59.1%	-33.6%
	24	15.1%	64.0%	-43.3%
	30	18.4%	68.1%	-54.8%
	36	21.5%	70.9%	-68.5%
	42	24.2%	73.2%	-78.9%
	48	26.5%	75.7%	-87.9%

Model parameters:				
fmin	0.40		alfa (1,1)	0.29
fmax	5.00		alfa (1,2)	0.14
kb	8.60		alfa (1,3)	0.10
psi	0.93		alfa (1,4)	0.00
kn	10.50		alfa (1,5)	0.00
nn	2.95		alfa (1,6)	0.00
			alfa (1,7)	0.00
			alfa (1.8)	0.00

Table 10.12 Sieg Level 1, Period no. 12, Sensitivity to LUA-NRW and DWD areal rainfall, in both computations **fmin=0.40** was used.

Sieg Level 1, Period no. 12, Differences due to areal rainfall according to LUA-NRW (fmin=0.40) data and DWD (fmin=0.20) data

	Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
Areal rainfall according to rainfall observed at **LUA-NRW** stations (**fmin=0.40**).	6	5.0%	23.0%	-27.5%
	12	8.6%	32.3%	-44.9%
	18	10.9%	42.0%	-49.8%
	24	13.2%	46.1%	-50.9%
	30	15.9%	53.7%	-48.4%
	36	18.6%	56.0%	-45.5%
	42	21.0%	56.0%	-54.0%
	48	23.0%	64.8%	-61.0%
Areal rainfall according to rainfall observed at **DWD** stations & relations between rainfall at DWD stations and areal rainfall according to LUA-NRW stations (**fmin=0.20**)	6	8.4%	29.5%	-77.7%
	12	17.3%	56.5%	-136.1%
	18	24.4%	78.8%	-154.9%
	24	30.7%	98.3%	-144.5%
	30	35.7%	114.6%	-144.5%
	36	39.7%	128.2%	-147.4%
	42	42.7%	141.3%	-150.0%
	48	45.4%	153.6%	-151.7%

Model parameters:				
fmin	0.20 or 0.40		alfa (1,1)	0.29
fmax	5.00		alfa (1,2)	0.14
kb	8.60		alfa (1,3)	0.10
psi	0.93		alfa (1,4)	0.00
kn	10.50		alfa (1,5)	0.00
nn	2.95		alfa (1,6)	0.00
			alfa (1,7)	0.00
			alfa (1.8)	0.00

Table 10.13 Sieg Level 1, Period no. 12, Sensitivity to LUA-NRW and DWD areal rainfall, **fmin=0.40** for LUA-NRW & **fmin = 0.20** for DWD.

Sieg Level 1, Period no. 12, *Differences due to areal rainfall according to* LUA-NRW (fmin=0.40) data and DWD (fmin=0.60) data

	Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
Areal rainfall according to rainfall observed at **LUA-NRW** stations (**fmin=0.40**).	6	5.0%	23.0%	-27.5%
	12	8.6%	32.3%	-44.9%
	18	10.9%	42.0%	-49.8%
	24	13.2%	46.1%	-50.9%
	30	15.9%	53.7%	-48.4%
	36	18.6%	56.0%	-45.5%
	42	21.0%	56.0%	-54.0%
	48	23.0%	64.8%	-61.0%
Areal rainfall according to rainfall observed at **DWD** stations & relations between rainfall at DWD stations and areal rainfall according to LUA-NRW stations (**fmin=0.60**)	6	5.2%	29.5%	-20.4%
	12	10.0%	45.1%	-18.7%
	18	14.0%	59.1%	-25.3%
	24	18.0%	64.0%	-31.4%
	30	21.4%	68.1%	-38.9%
	36	24.7%	70.9%	-45.5%
	42	28.0%	73.2%	-54.0%
	48	30.8%	75.7%	-61.0%

Model parameters:				
fmin	0.40 or 0.60		alfa (1,1)	0.29
fmax	5.00		alfa (1,2)	0.14
kb	8.60		alfa (1,3)	0.10
psi	0.93		alfa (1,4)	0.00
kn	10.50		alfa (1,5)	0.00
nn	2.95		alfa (1,6)	0.00
			alfa (1,7)	0.00
			alfa (1.8)	0.00

Table 10.14 Sieg Level 1, Period no. 12, Sensitivity to LUA-NRW and DWD areal rainfall, **fmin=0.40** for LUA-NRW & **fmin = 0.60** for DWD.

Lippe Level 1, Period no. 7, Differences due to areal rainfall according to LUA-NRW (fmin=0.20) data and DWD (fmin=0.20) data

	Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
Areal rainfall according to rainfall observed at **LUA-NRW** stations (**fmin=0.20**).	6	2.8%	11.7%	-19.2%
	12	5.7%	21.3%	-27.3%
	18	8.3%	32.3%	-33.9%
	24	10.1%	39.1%	-38.1%
	30	11.4%	44.2%	-47.3%
	36	12.7%	46.6%	-48.9%
	42	14.2%	47.4%	-54.7%
	48	15.7%	49.6%	-62.7%
	54	17.4%	51.8%	-66.7%
	60	19.4%	53.8%	-76.8%
Areal rainfall according to rainfall observed at **DWD** stations & relations between rainfall at DWD stations and areal rainfall according to LUA-NRW stations (**fmin=0.20**)	6	2.9%	12.8%	-19.6%
	12	5.9%	18.0%	-27.3%
	18	8.5%	23.6%	-37.8%
	24	10.2%	28.3%	-46.0%
	30	11.3%	31.3%	-44.6%
	36	12.4%	32.3%	-41.5%
	42	13.6%	34.7%	-43.6%
	48	14.6%	37.4%	-49.9%
	54	15.9%	39.5%	-52.6%
	60	17.2%	41.5%	-61.3%

Model parameters:				
fmin	0.20		alfa (1,1)	0.29
fmax	5.00		alfa (1,2)	0.14
kb	8.60		alfa (1,3)	0.10
psi	0.93		alfa (1,4)	0.00
kn	10.50		alfa (1,5)	0.00
nn	2.95		alfa (1,6)	0.00
			alfa (1,7)	0.00
			alfa (1.8)	0.00
			alfa (1,9)	0.00
			alfa (1.10)	0.00

Table 10.15 Lippe Level 1, Period no. 7, Sensitivity to LUA-NRW and DWD areal rainfall, in both computations **fmin=0.20** was used.

Lippe Level 1, Period no. 7, Differences due to areal rainfall according to LUA-NRW (fmin=0.20) data and DWD (fmin=0.10) data

	Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
Areal rainfall according to rainfall observed at **LUA-NRW** stations (**fmin=0.20**).	6	2.8%	11.7%	-19.2%
	12	5.7%	21.3%	-27.3%
	18	8.3%	32.3%	-33.9%
	24	10.1%	39.1%	-38.1%
	30	11.4%	44.2%	-47.3%
	36	12.7%	46.6%	-48.9%
	42	14.2%	47.4%	-54.7%
	48	15.7%	49.6%	-62.7%
	54	17.4%	51.8%	-66.7%
	60	19.4%	53.8%	-76.8%
Areal rainfall according to rainfall observed at **DWD** stations & relations between rainfall at DWD stations and areal rainfall according to LUA-NRW stations (**fmin=0.10**)	6	3.5%	40.1%	-69.4%
	12	7.1%	35.7%	-73.7%
	18	10.3%	22.6%	-87.6%
	24	12.5%	28.6%	-95.7%
	30	14.3%	37.4%	-92.7%
	36	15.8%	43.4%	-89.6%
	42	17.5%	50.5%	-86.3%
	48	19.1%	56.9%	-83.3%
	54	20.8%	63.2%	-78.0%
	60	22.5%	69.9%	-82.6%

Model parameters:				
fmin	0.20 or 0.10		alfa (1,1)	0.29
fmax	5.00		alfa (1,2)	0.14
kb	8.60		alfa (1,3)	0.10
psi	0.93		alfa (1,4)	0.00
kn	10.50		alfa (1,5)	0.00
nn	2.95		alfa (1,6)	0.00
			alfa (1,7)	0.00
			alfa (1.8)	0.00
			alfa (1,9)	0.00
			alfa (1.10)	0.00

Table 10.16 Lippe Level 1, Period no. 7, Sensitivity to LUA-NRW and DWD areal rainfall, **fmin=0.20** for LUA-NRW & **fmin = 0.10** for DWD.

Lippe Level 1, Period no. 7, Differences due to areal rainfall according to LUA-NRW (fmin=0.20) data and DWD (fmin=0.30) data

	Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
Areal rainfall according to rainfall observed at **LUA-NRW** stations (**fmin=0.20**).	6	2.8%	11.7%	-19.2%
	12	5.7%	21.3%	-27.3%
	18	8.3%	32.3%	-33.9%
	24	10.1%	39.1%	-38.1%
	30	11.4%	44.2%	-47.3%
	36	12.7%	46.6%	-48.9%
	42	14.2%	47.4%	-54.7%
	48	15.7%	49.6%	-62.7%
	54	17.4%	51.8%	-66.7%
	60	19.4%	53.8%	-76.8%
Areal rainfall according to rainfall observed at **DWD** stations & relations between rainfall at DWD stations and areal rainfall according to LUA-NRW stations (**fmin=0.30**)	6	2.8%	11.7%	-19.2%
	12	5.6%	18.5%	-27.3%
	18	8.1%	24.7%	-33.9%
	24	9.7%	29.9%	-38.1%
	30	11.0%	33.6%	-47.3%
	36	12.2%	37.6%	-48.9%
	42	13.7%	41.7%	-54.7%
	48	15.2%	45.3%	-62.7%
	54	16.8%	48.4%	-66.7%
	60	18.6%	51.2%	-76.8%

Model parameters:				
fmin	0.20 or 0.30		alfa (1,1)	0.29
fmax	5.00		alfa (1,2)	0.14
kb	8.60		alfa (1,3)	0.10
psi	0.93		alfa (1,4)	0.00
kn	10.50		alfa (1,5)	0.00
nn	2.95		alfa (1,6)	0.00
			alfa (1,7)	0.00
			alfa (1.8)	0.00
			alfa (1,9)	0.00
			alfa (1.10)	0.00

Table 10.17 Lippe Level 1, Period no. 7, Sensitivity to LUA-NRW and DWD areal rainfall, **fmin=0.20** for LUA-NRW & **fmin = 0.30** for DWD.

Lippe Level 1, Period no. 9, Differences due to areal rainfall according to LUA-NRW (fmin=0.20) data and DWD (fmin=0.20) data

	Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
Areal rainfall according to rainfall observed at **LUA-NRW** stations (**fmin=0.20**).	6	3.8%	15.2%	-14.1%
	12	7.3%	33.9%	-33.3%
	18	9.7%	48.7%	-37.7%
	24	11.2%	52.9%	-37.7%
	30	12.6%	56.0%	-32.3%
	36	13.8%	54.3%	-35.4%
	42	14.9%	51.1%	-38.8%
	48	16.1%	55.7%	-40.1%
	54	17.4%	58.6%	-43.8%
	60	18.5%	60.7%	-49.6%
Areal rainfall according to rainfall observed at **DWD** stations & relations between rainfall at DWD stations and areal rainfall according to LUA-NRW stations (**fmin=0.20**)	6	4.0%	15.2%	-22.4%
	12	8.4%	33.9%	-33.3%
	18	12.1%	48.7%	-41.7%
	24	14.5%	55.2%	-57.5%
	30	17.0%	66.4%	-68.4%
	36	19.2%	76.8%	-80.2%
	42	21.2%	86.3%	-96.5%
	48	23.1%	94.1%	-108.2%
	54	25.2%	99.4%	-111.7%
	60	26.8%	103.4%	-113.3%

Model parameters:				
fmin	0.20		alfa (1,1)	0.29
fmax	5.00		alfa (1,2)	0.14
kb	8.60		alfa (1,3)	0.10
psi	0.93		alfa (1,4)	0.00
kn	10.50		alfa (1,5)	0.00
nn	2.95		alfa (1,6)	0.00
			alfa (1,7)	0.00
			alfa (1.8)	0.00
			alfa (1,9)	0.00
			alfa (1.10)	0.00

Table 10.18 Lippe Level 1, Period no. 9, Sensitivity to LUA-NRW and DWD areal rainfall, in both computations **fmin=0.20** was used.

Lippe Level 1, Period no. 9, Differences due to areal rainfall according to LUA-NRW (fmin=0.20) data and DWD (fmin=0.10) data

	Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
Areal rainfall according to rainfall observed at **LUA-NRW** stations (**fmin=0.20**).	6	3.8%	15.2%	-14.1%
	12	7.3%	33.9%	-33.3%
	18	9.7%	48.7%	-37.7%
	24	11.2%	52.9%	-37.7%
	30	12.6%	56.0%	-32.3%
	36	13.8%	54.3%	-35.4%
	42	14.9%	51.1%	-38.8%
	48	16.1%	55.7%	-40.1%
	54	17.4%	58.6%	-43.8%
	60	18.5%	60.7%	-49.6%
Areal rainfall according to rainfall observed at **DWD** stations & relations between rainfall at DWD stations and areal rainfall according to LUA-NRW stations (**fmin=0.10**)	6	4.2%	15.2%	-26.8%
	12	9.5%	33.9%	-41.0%
	18	14.2%	48.9%	-54.5%
	24	17.2%	64.1%	-64.4%
	30	20.3%	77.6%	-79.3%
	36	23.2%	89.0%	-94.9%
	42	26.0%	97.9%	-114.3%
	48	28.5%	106.3%	-125.2%
	54	31.0%	113.7%	-132.5%
	60	33.3%	118.9%	-142.0%

Model parameters:				
fmin	0.10 or 0.20		alfa (1,1)	0.29
fmax	5.00		alfa (1,2)	0.14
kb	8.60		alfa (1,3)	0.10
psi	0.93		alfa (1,4)	0.00
kn	10.50		alfa (1,5)	0.00
nn	2.95		alfa (1,6)	0.00
			alfa (1,7)	0.00
			alfa (1.8)	0.00
			alfa (1,9)	0.00
			alfa (1.10)	0.00

Table 10.19 Lippe Level 1, Period no. 9, Sensitivity to LUA-NRW and DWD areal rainfall, **fmin=0.20** for LUA-NRW & **fmin = 0.10** for DWD.

Lippe Level 1, Period no. 9, Differences due to areal rainfall according to LUA-NRW (fmin=0.20) data and DWD (fmin=0.30) data

	Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
Areal rainfall according to rainfall observed at **LUA-NRW** stations (**fmin=0.20**).	6	3.8%	15.2%	-14.1%
	12	7.3%	33.9%	-33.3%
	18	9.7%	48.7%	-37.7%
	24	11.2%	52.9%	-37.7%
	30	12.6%	56.0%	-32.3%
	36	13.8%	54.3%	-35.4%
	42	14.9%	51.1%	-38.8%
	48	16.1%	55.7%	-40.1%
	54	17.4%	58.6%	-43.8%
	60	18.5%	60.7%	-49.6%
Areal rainfall according to rainfall observed at **DWD** stations & relations between rainfall at DWD stations and areal rainfall according to LUA-NRW stations (**fmin=0.30**)	6	3.9%	15.2%	-16.7%
	12	8.1%	33.9%	-33.3%
	18	11.2%	48.7%	-40.3%
	24	13.2%	52.9%	-53.1%
	30	15.0%	56.0%	-63.8%
	36	16.6%	60.8%	-69.8%
	42	18.3%	67.4%	-74.9%
	48	20.0%	73.9%	-83.8%
	54	21.9%	79.9%	-88.9%
	60	23.5%	82.4%	-87.8%

Model parameters:				
fmin	0.20 or 0.30		alfa (1,1)	0.29
fmax	5.00		alfa (1,2)	0.14
kb	8.60		alfa (1,3)	0.10
psi	0.93		alfa (1,4)	0.00
kn	10.50		alfa (1,5)	0.00
nn	2.95		alfa (1,6)	0.00
			alfa (1,7)	0.00
			alfa (1.8)	0.00
			alfa (1,9)	0.00
			alfa (1.10)	0.00

Table 10.20 Lippe Level 1, Period no. 9, Sensitivity to LUA-NRW and DWD areal rainfall, **fmin=0.20** for LUA-NRW & **fmin = 0.30** for DWD.

Figures of Chapter 2

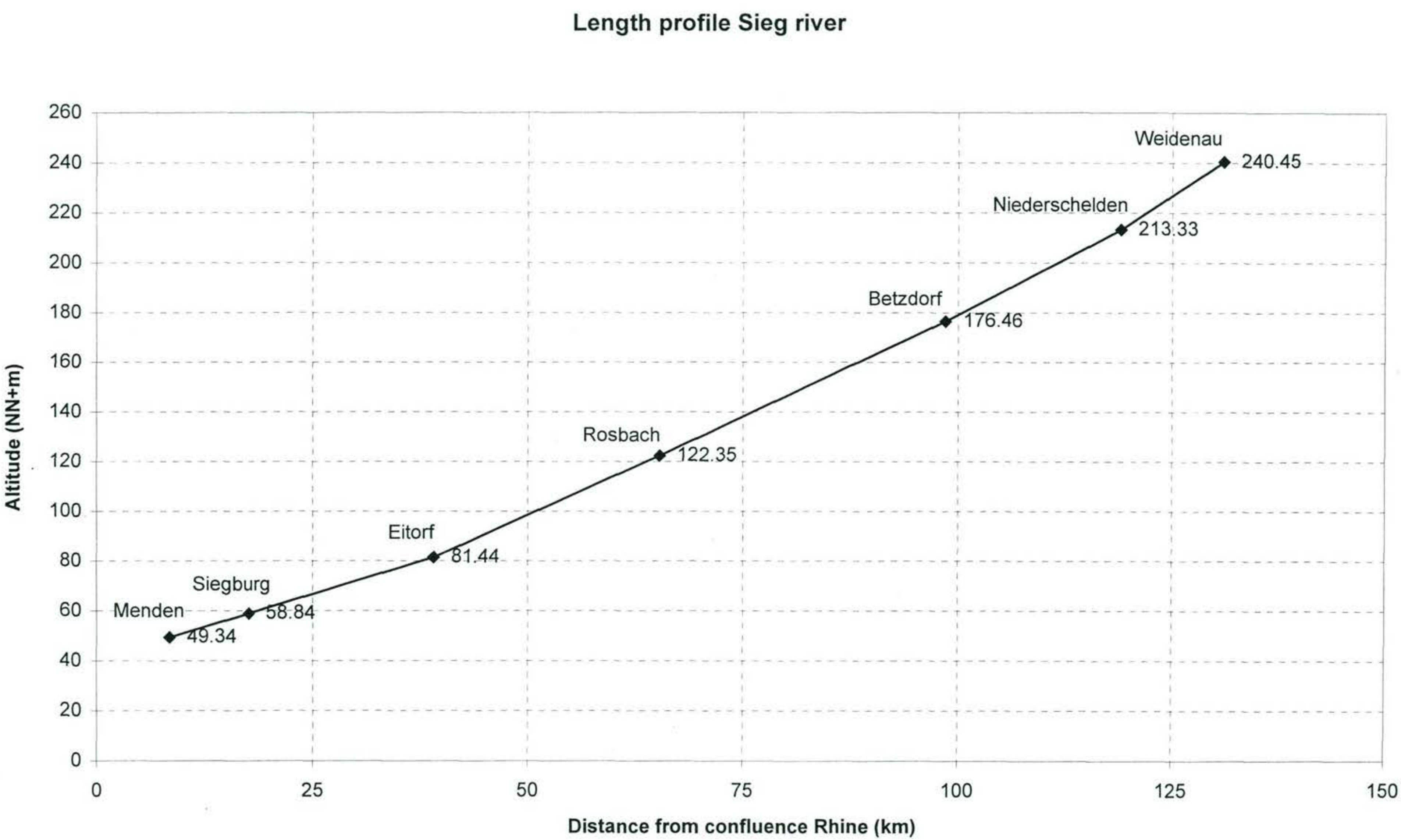


Fig. 2.1 Length profile of the Sieg river

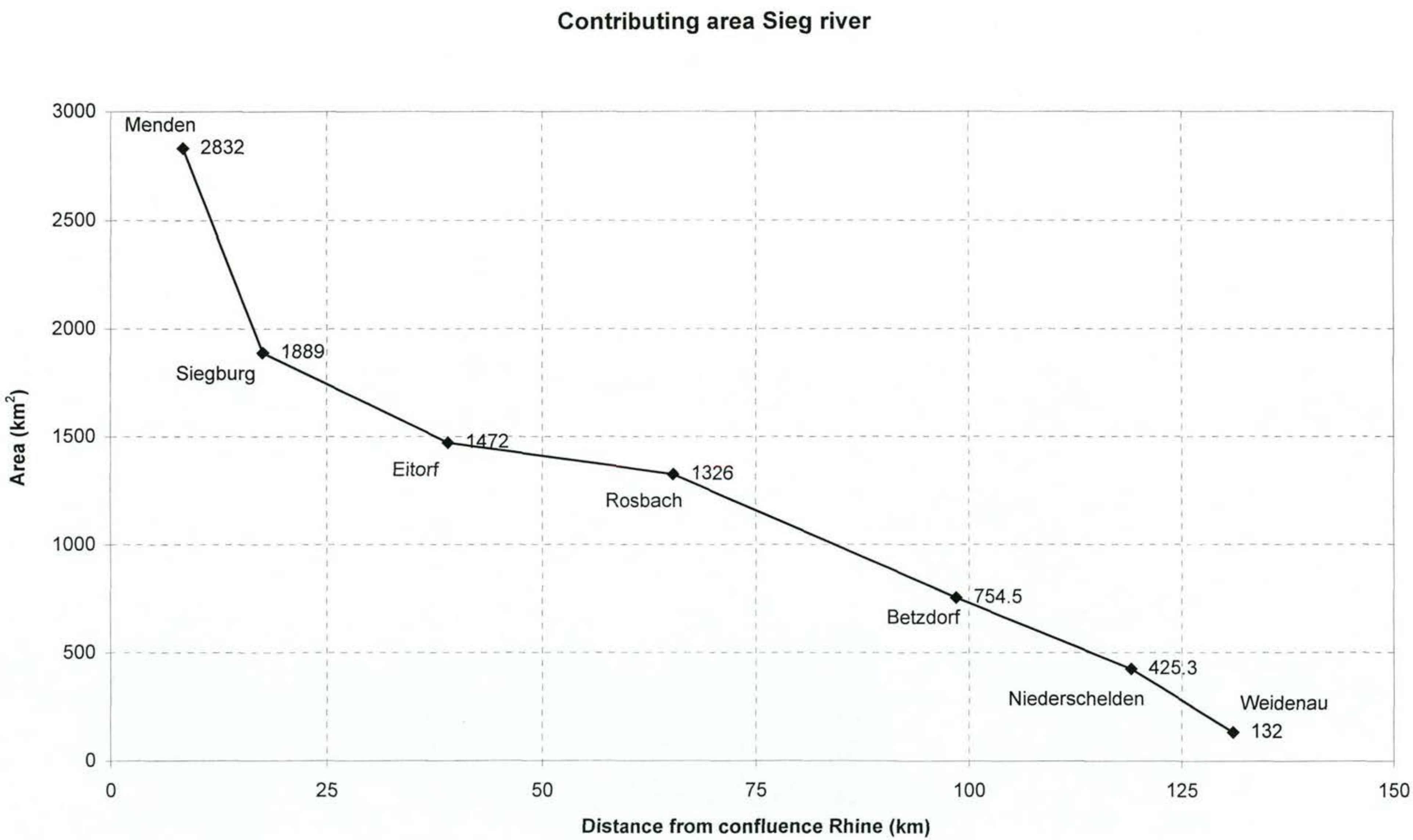


Fig. 2.2 Contributing area of the Sieg river

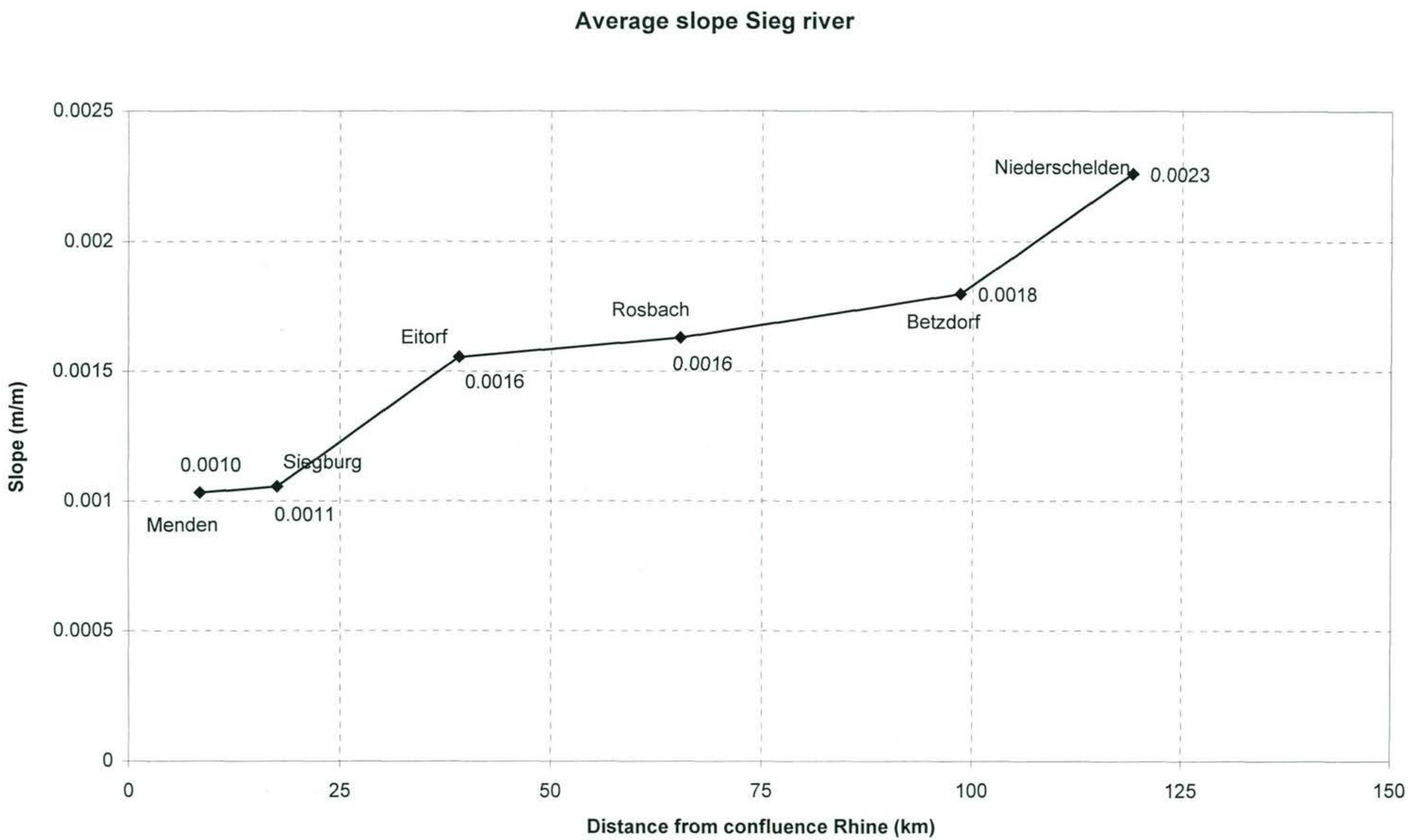
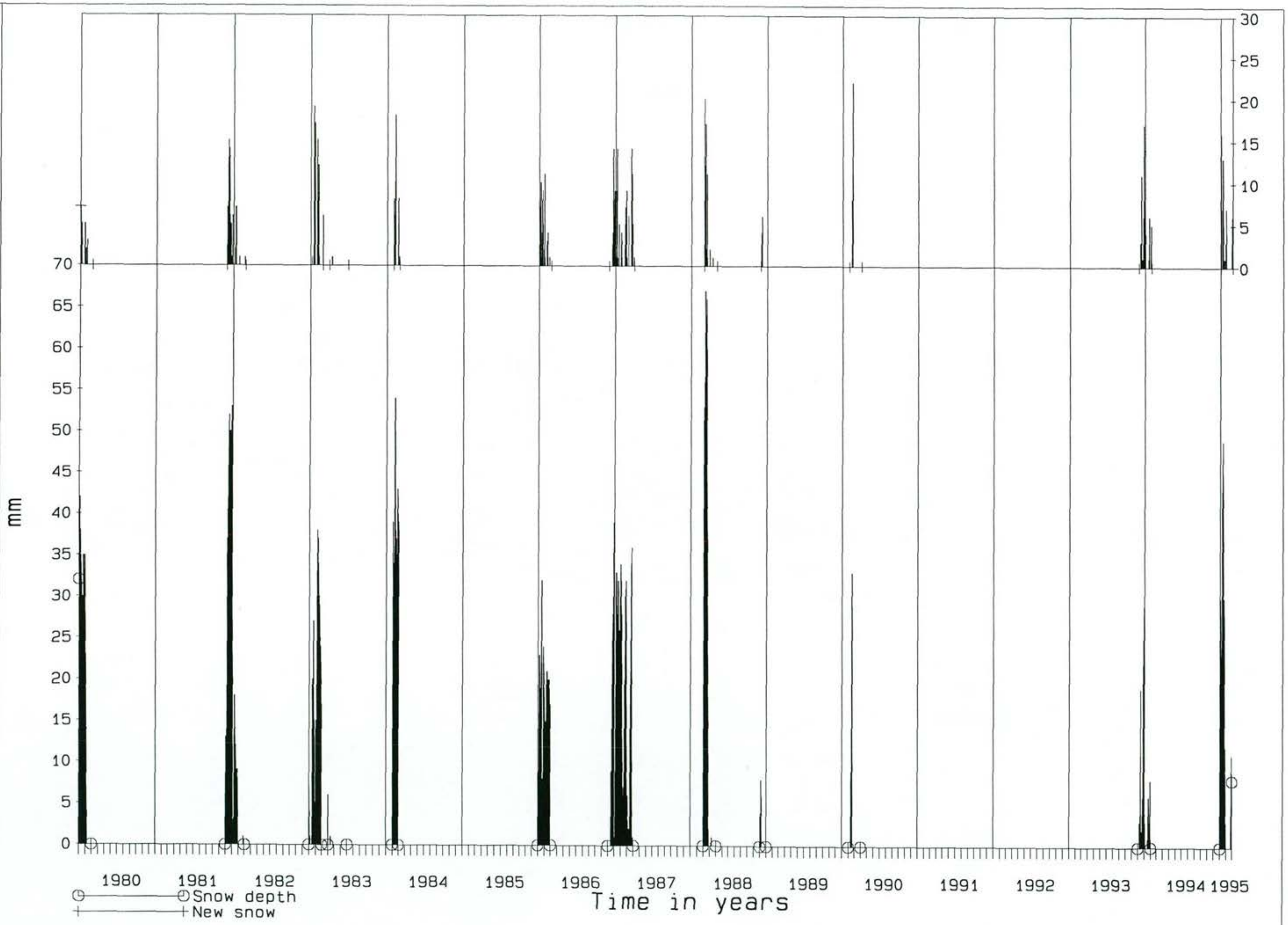


Fig. 2.3 Average slope of the Sieg river



DELFT HYDRAULICS

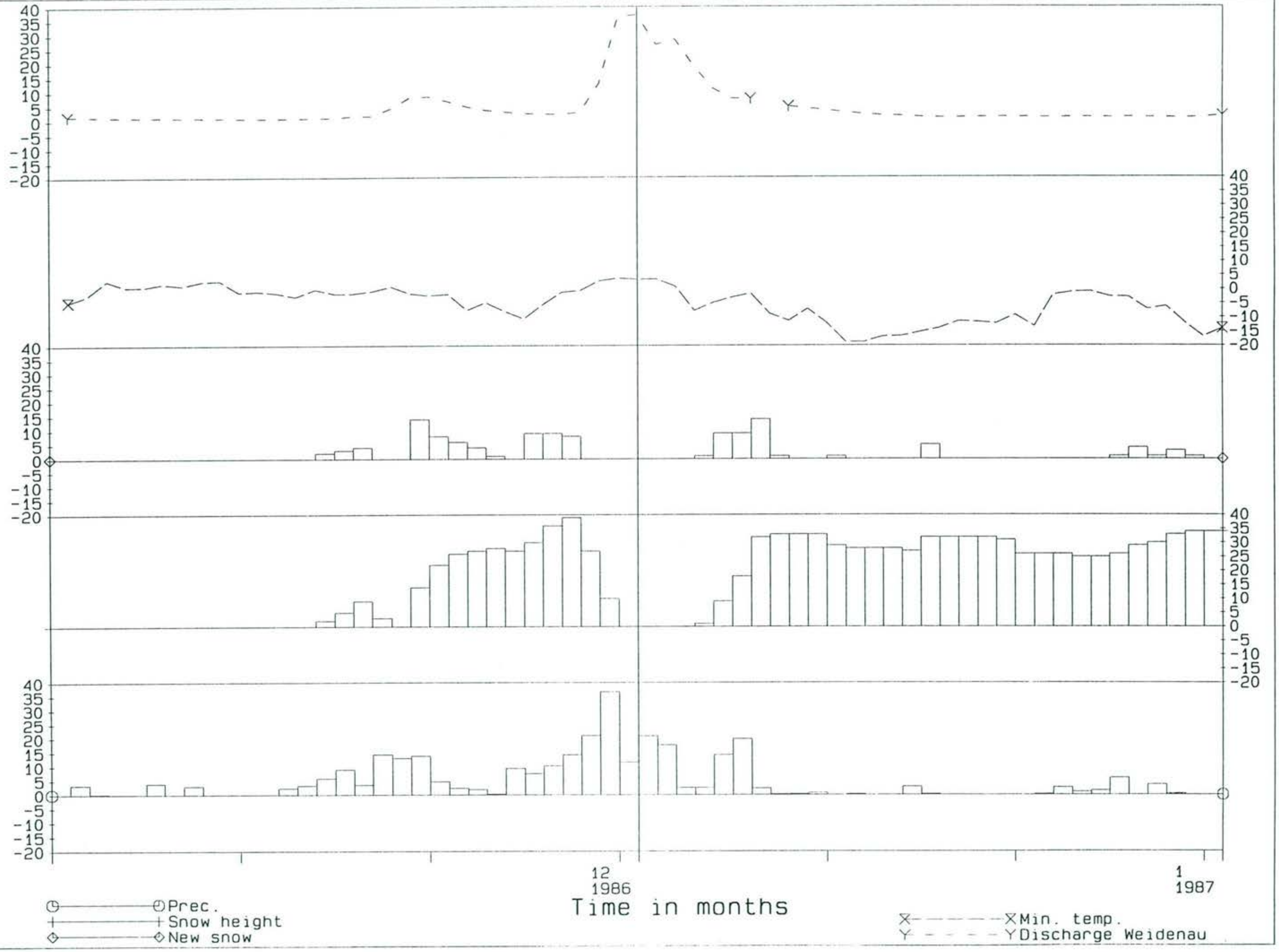
Snow at Bad-Marienberg (Upper Sieg)
Period 1980 - 1995

R3049

FIG. 2.4

DELFT HYDRAULICS

Flood generation Upper basin Sieg
Period Dec. 1986 - Jan. 1987



R3049

FIG. 2.5

Precipitation - discharge relationship
Agger
Flood January 1980

DELFT HYDRAULICS

R3049

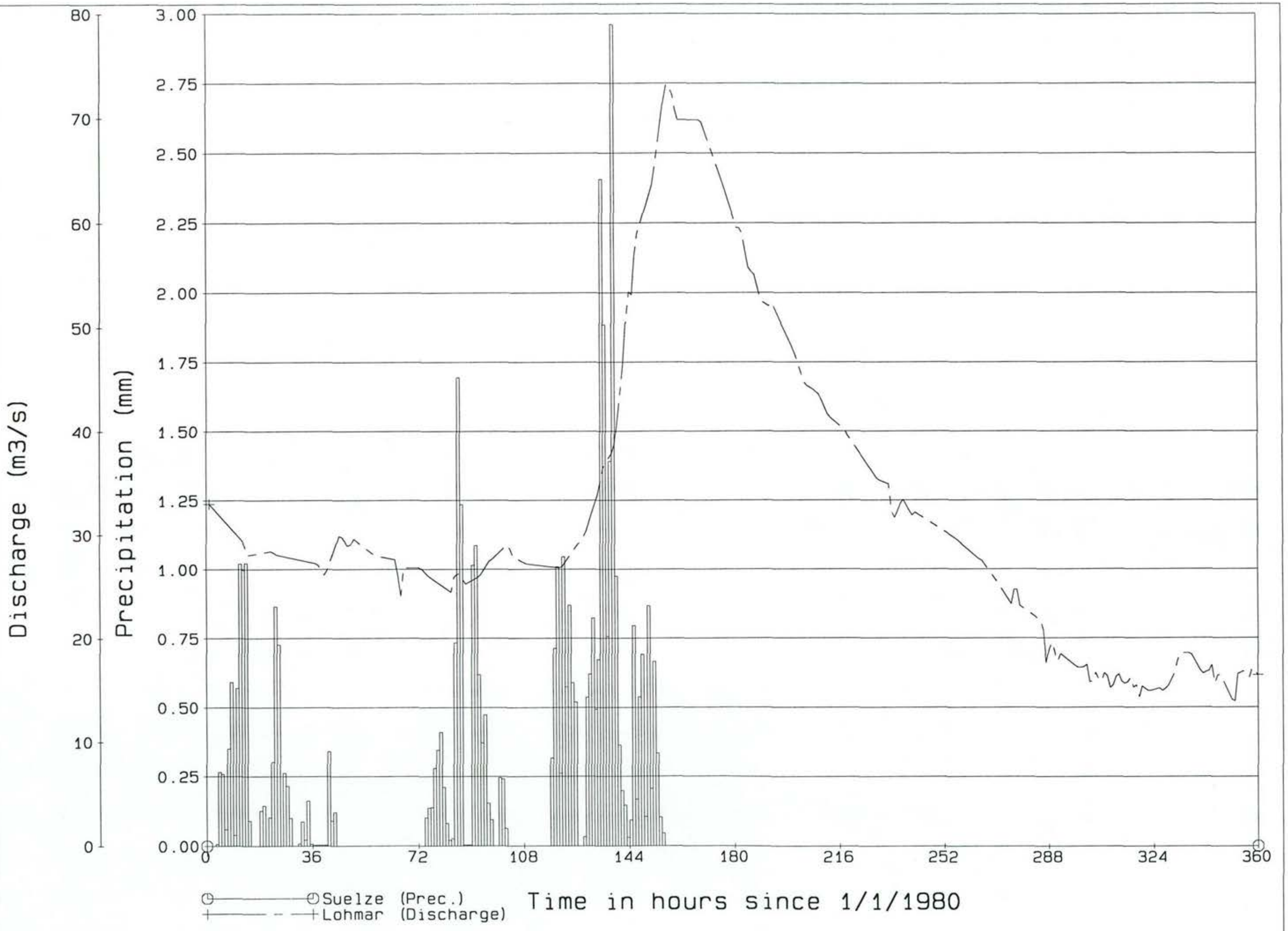
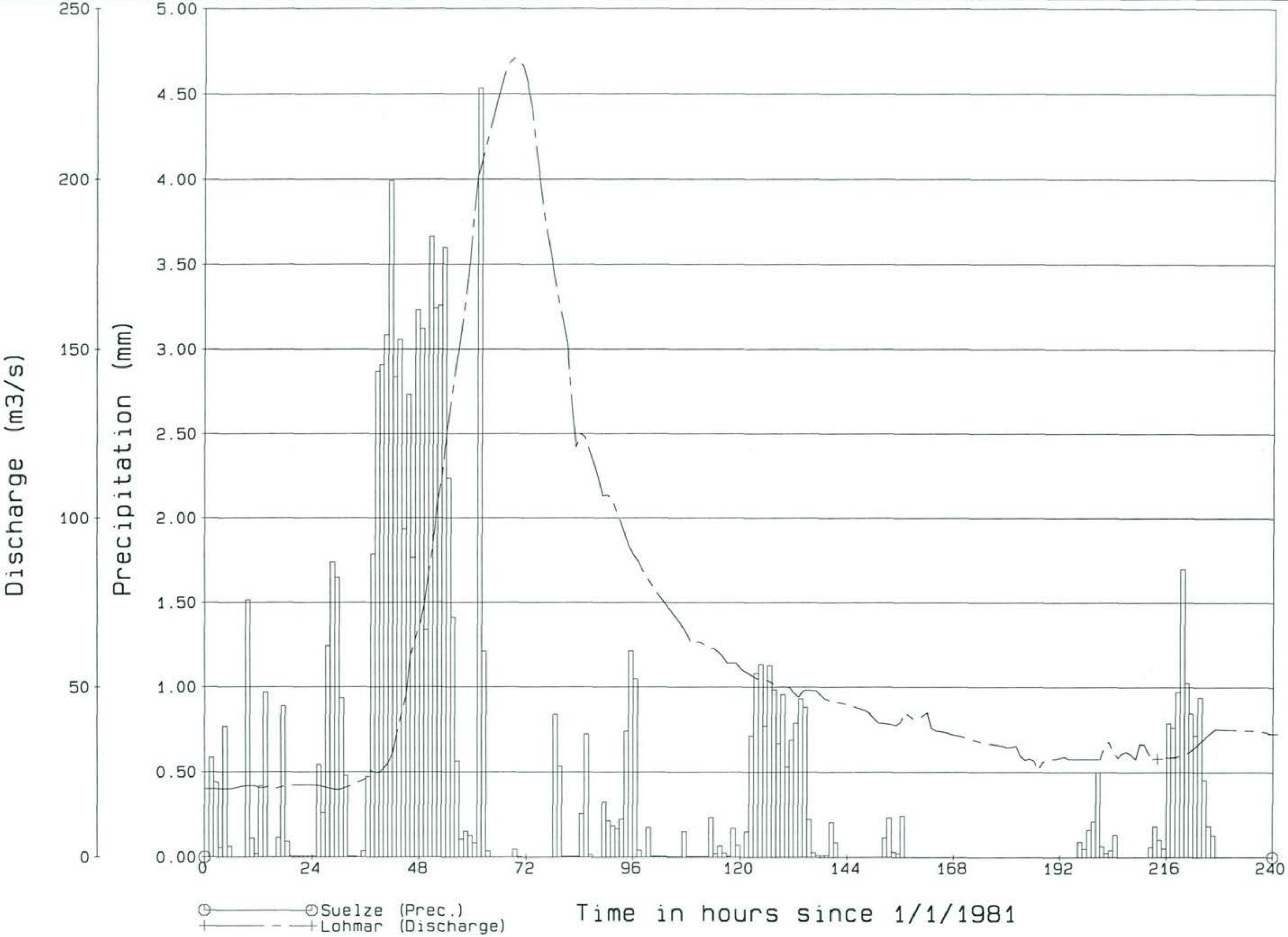


FIG. 2.6

DELFT HYDRAULICS

Precipitation - discharge relationship
Agger
Flood January 1981



R3049

FIG. 2.7

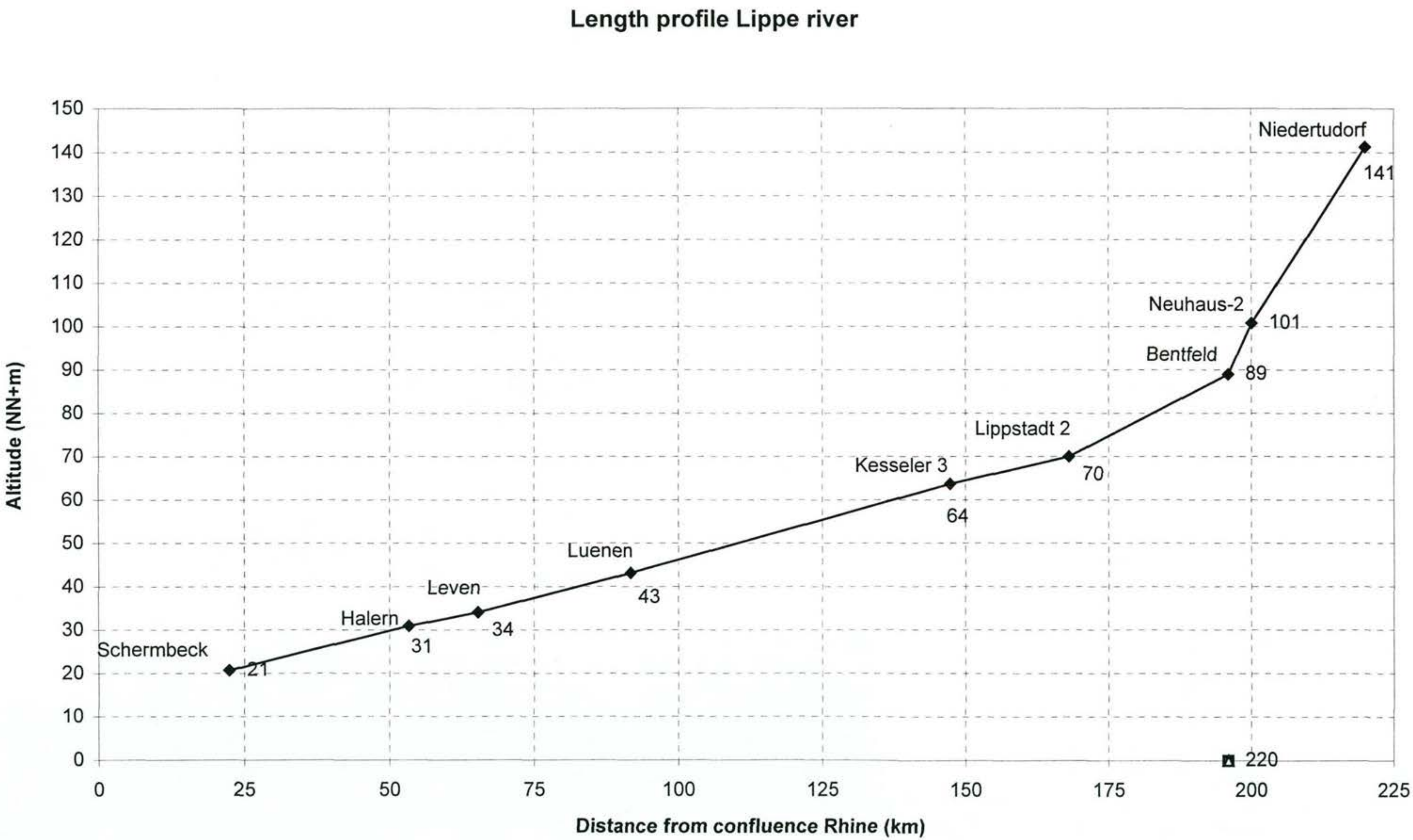


Fig. 2.8 Length profile of the Lippe river

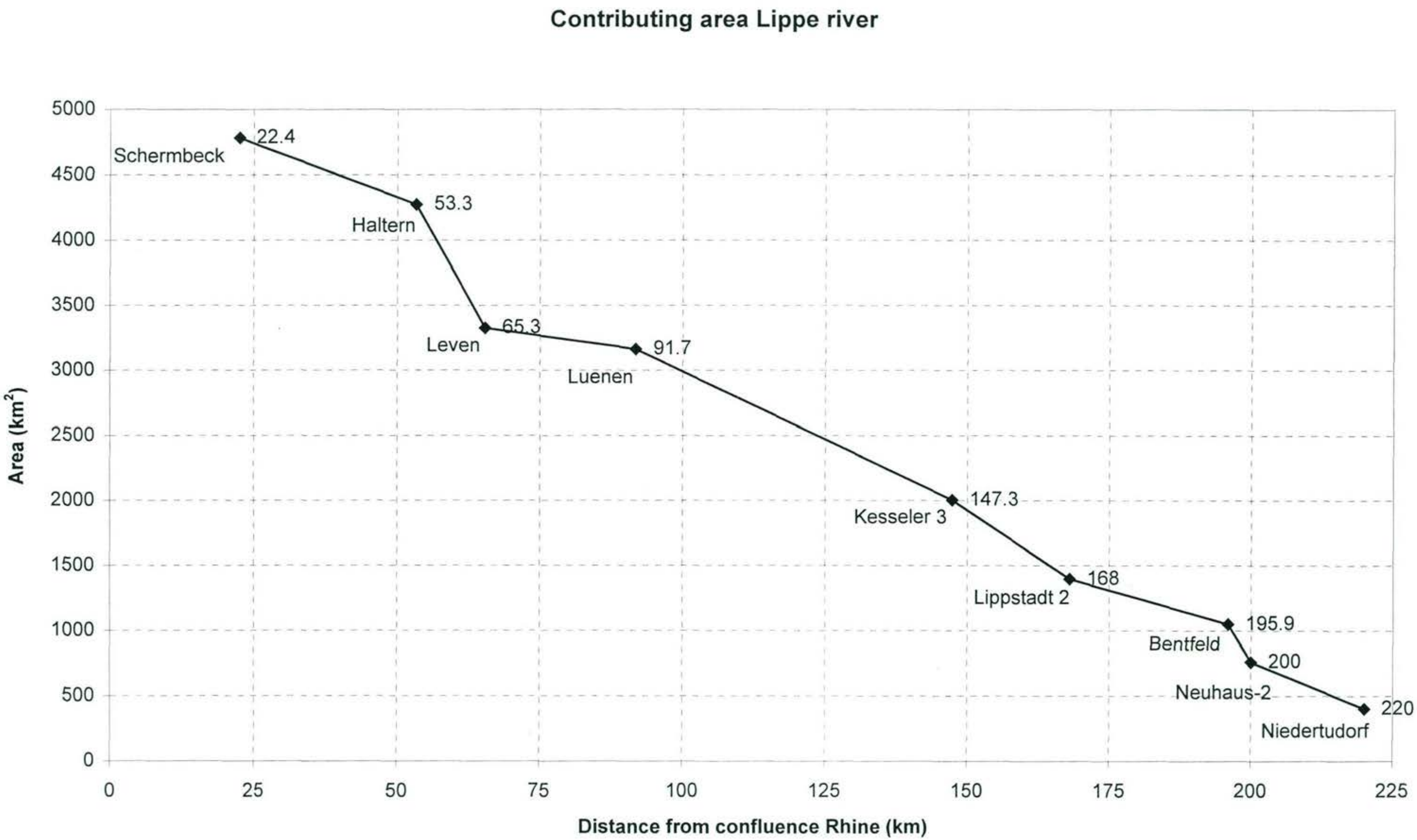


Fig. 2.9 Contributing area of the Lippe river

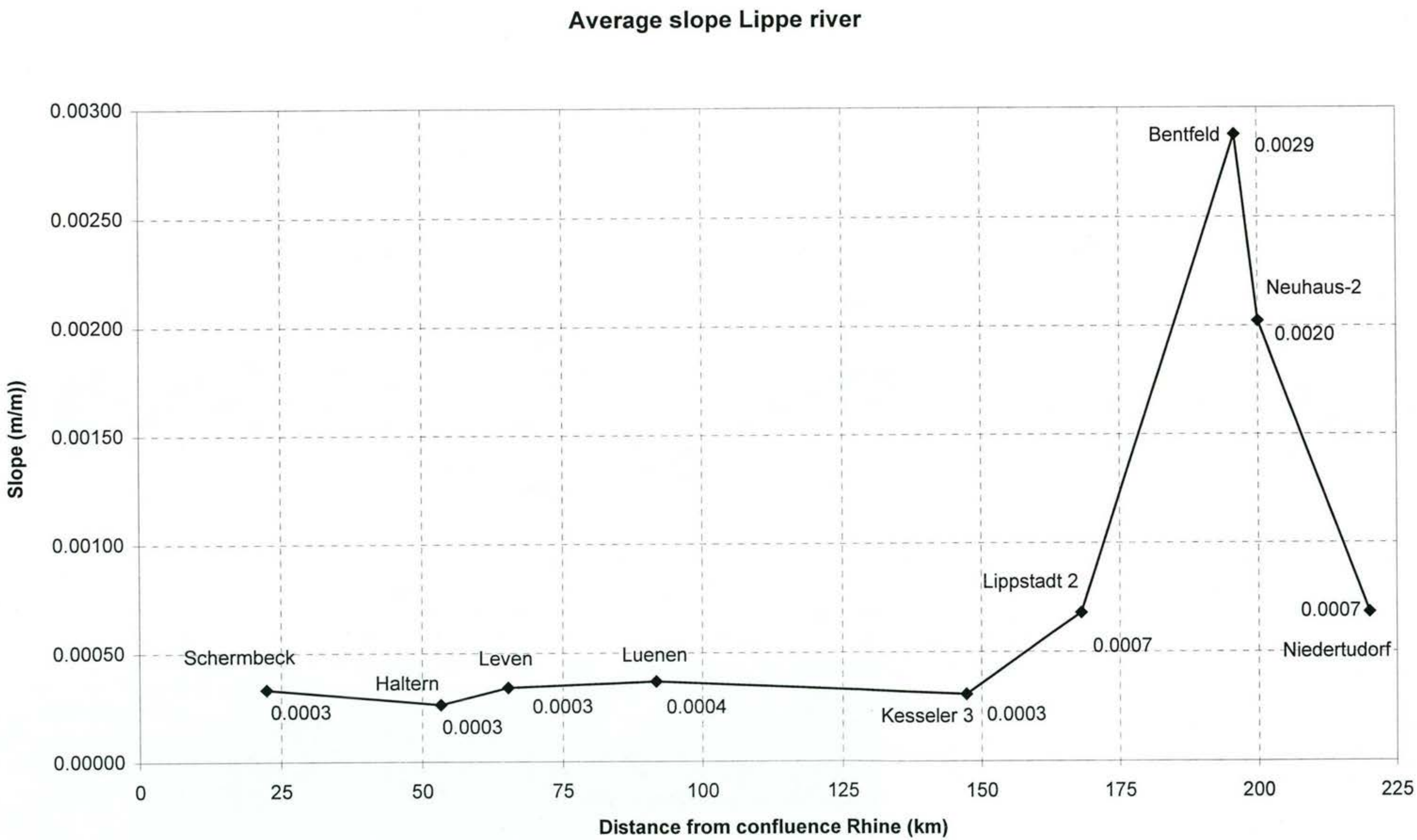
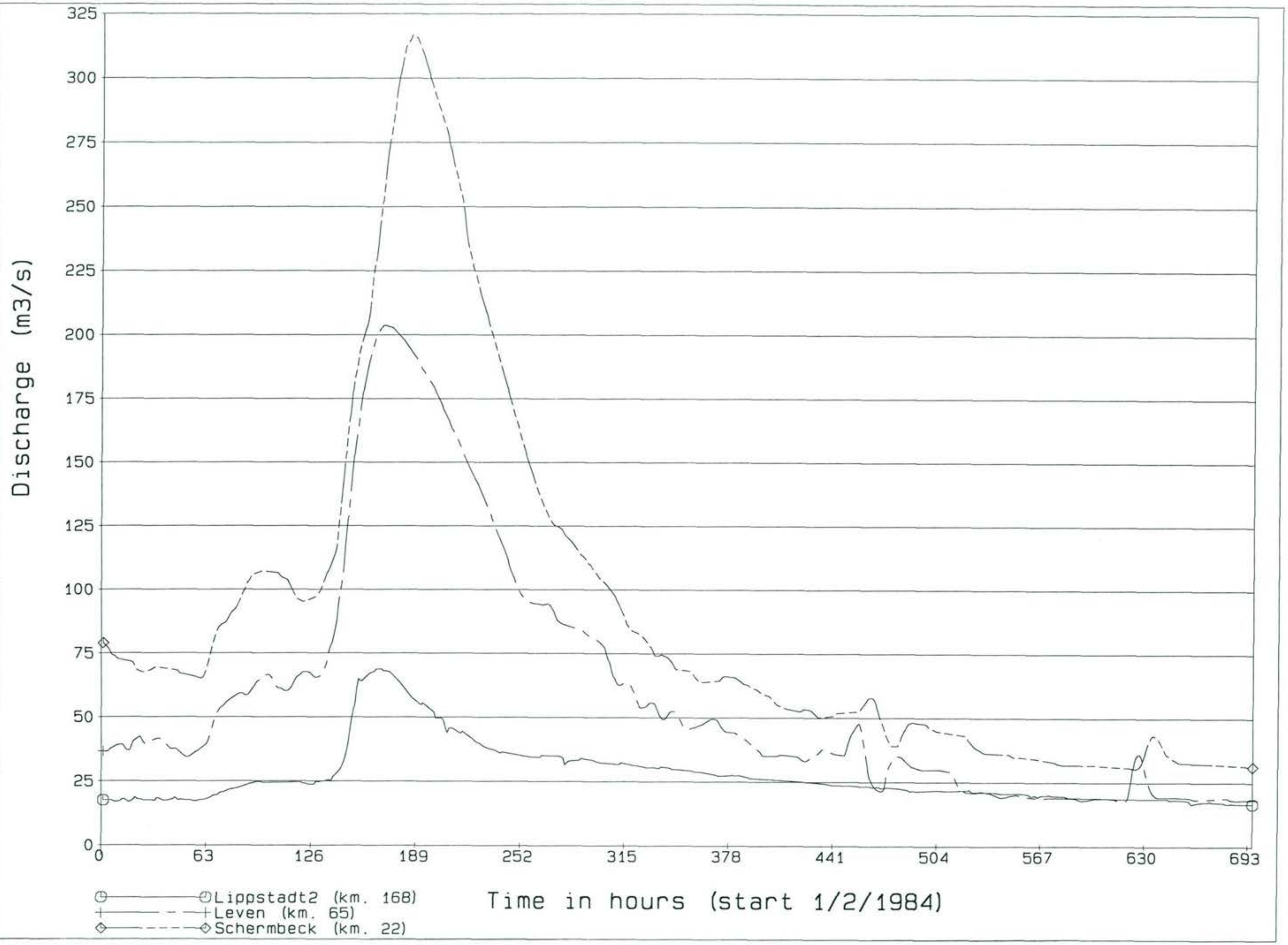


Fig. 2.10 Average slope of the Lippe river

Flood peak Lippe
Period February 1984
Stations Lippstadt2, Leven, Schermbeck



DELFT HYDRAULICS

R3049

FIG. 2.11

Flood peak Lippe
Period May-June 1984
Stations Lippstadt2, Leven, Schermbeck

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R3049

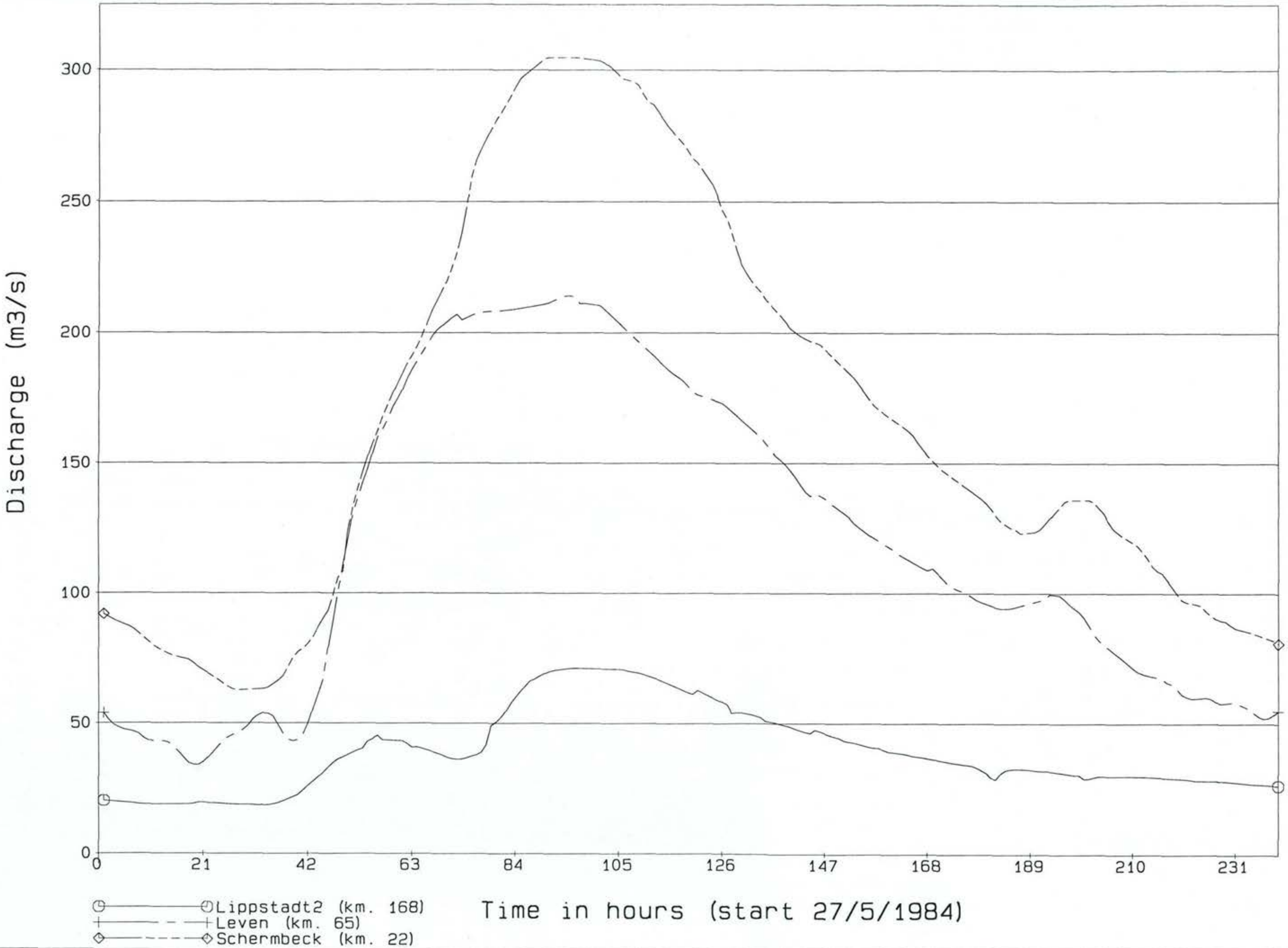
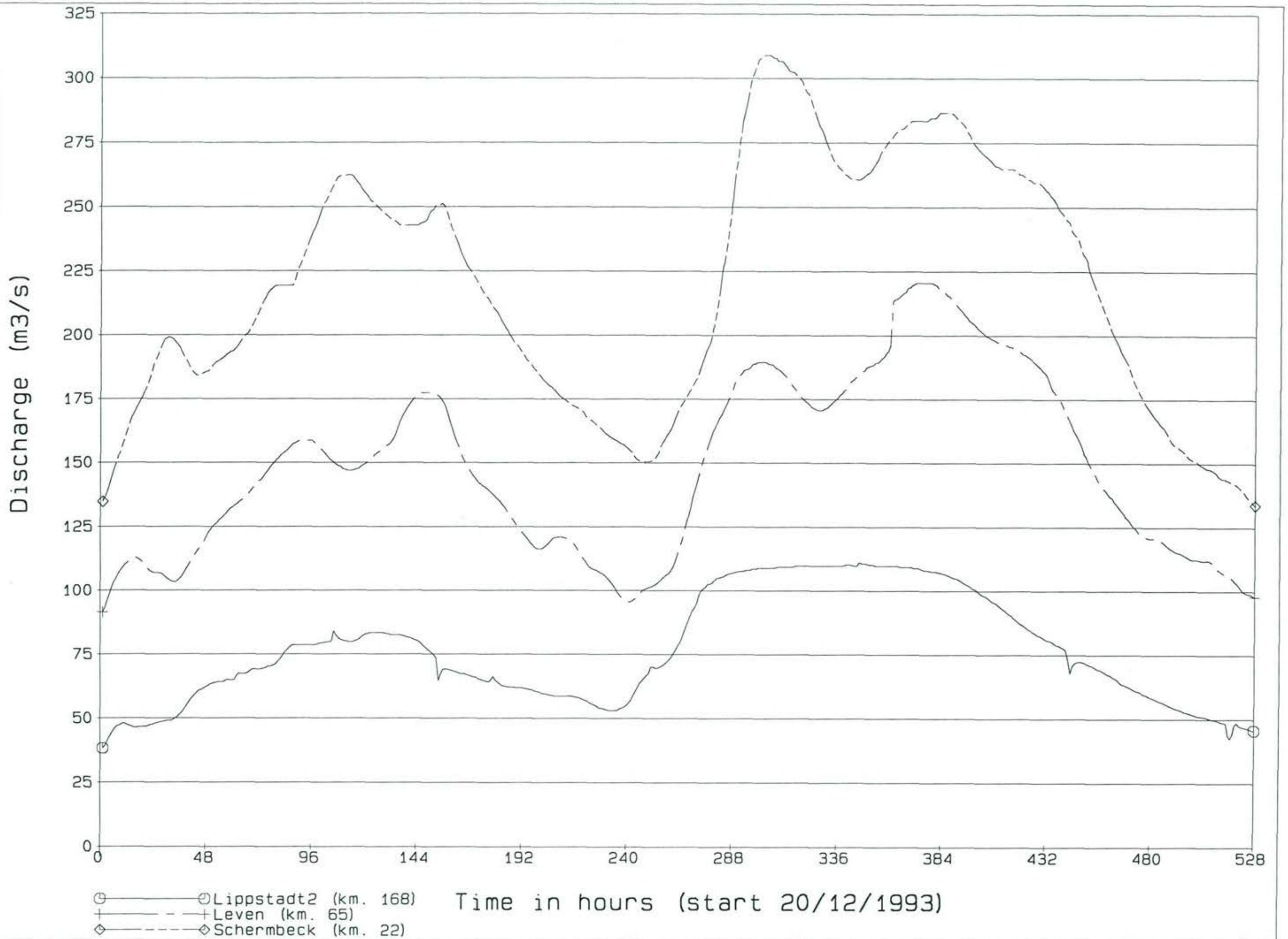


FIG. 2.12

Flood peak Lippe
Period Dec. 1993 - Jan. 1994
Stations Lippstadt2, Leven, Schermbeck

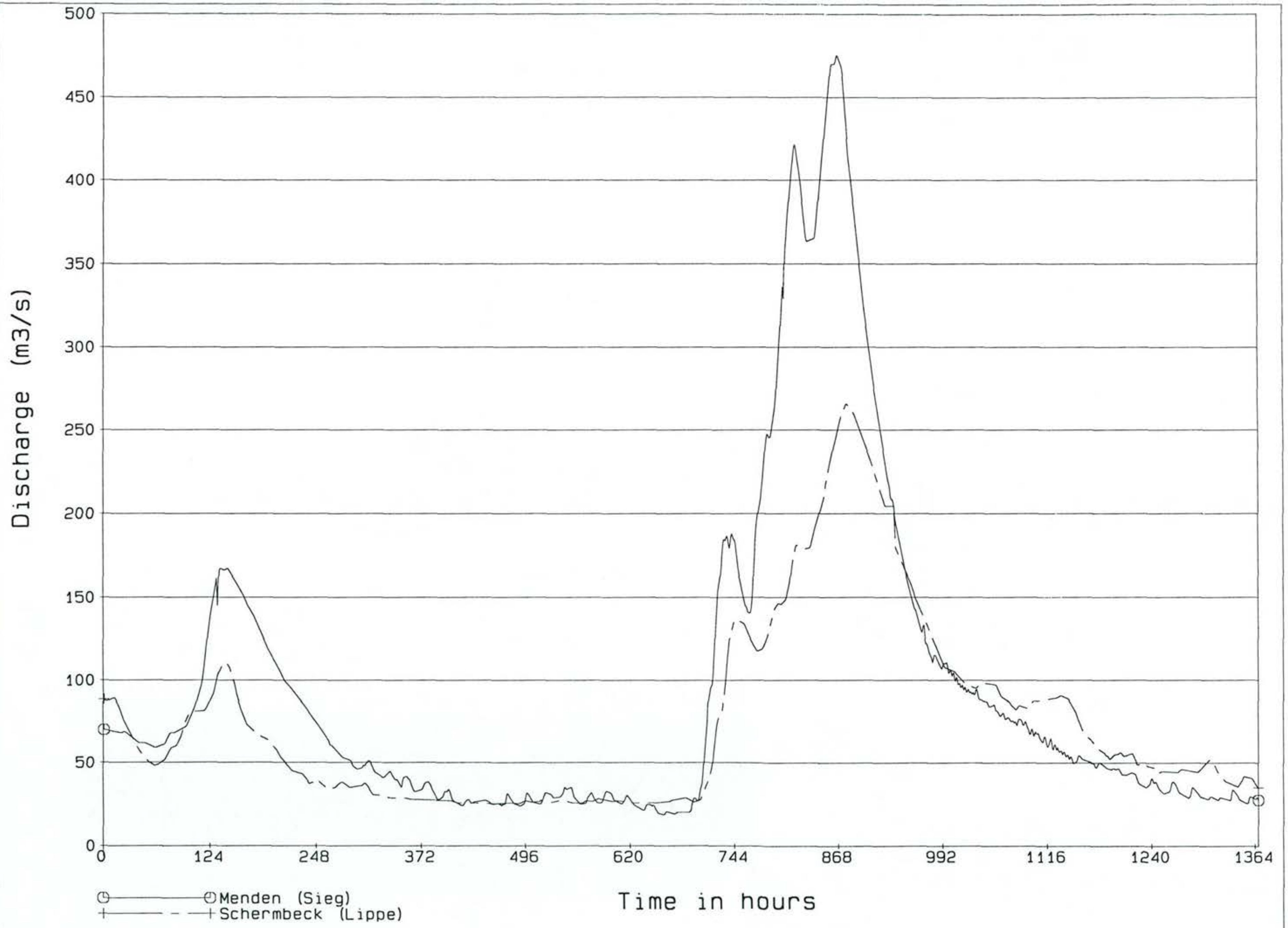


DELFT HYDRAULICS

R3049

FIG. 2.13

Hydrographs Sieg and Lippe
Stations Menden and Schermbeck
Period 1: 1/1/1980 - 29/2/1980



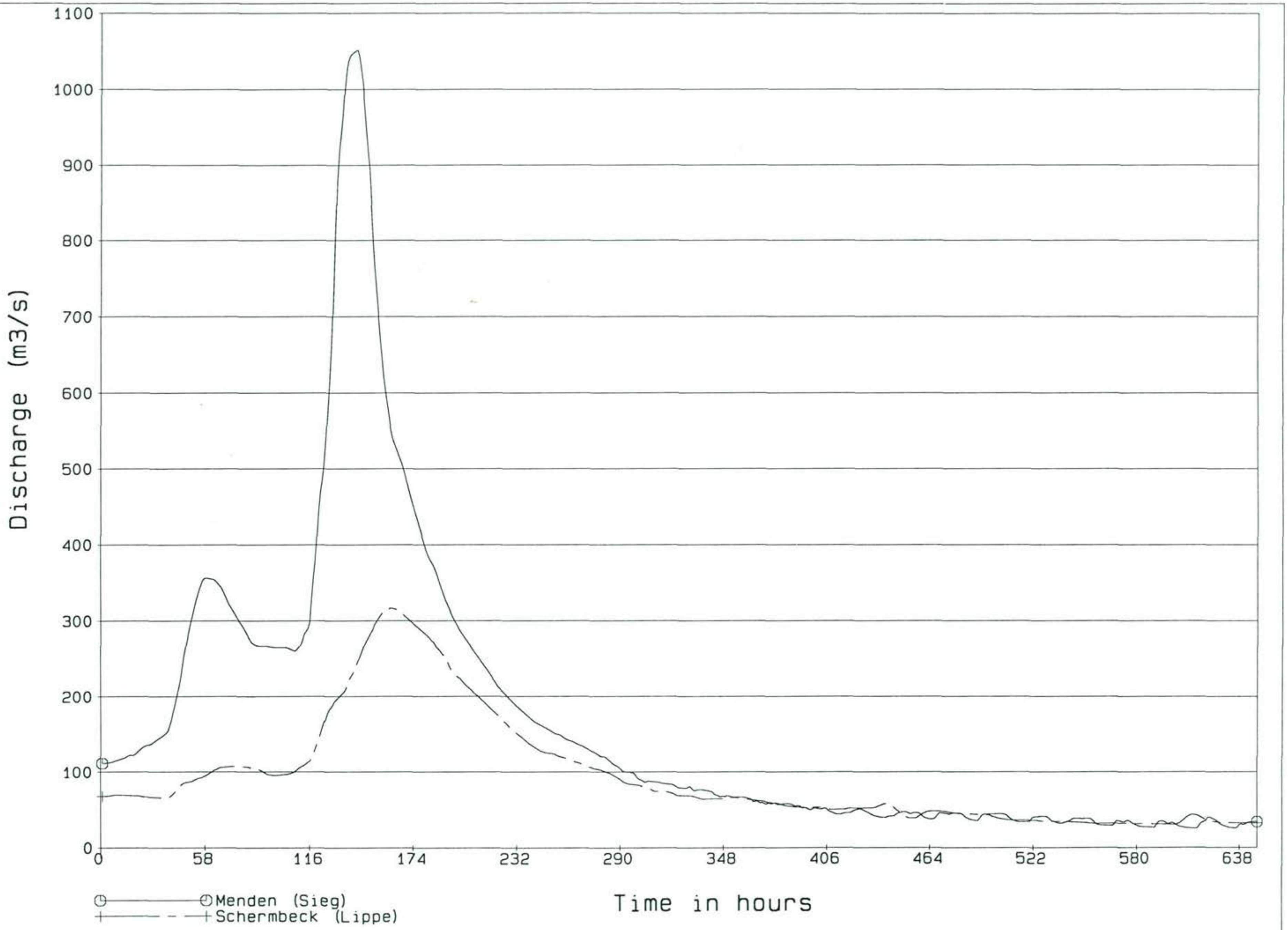
DELFT HYDRAULICS

R3049

FIG. 2.14.1

DELFT HYDRAULICS

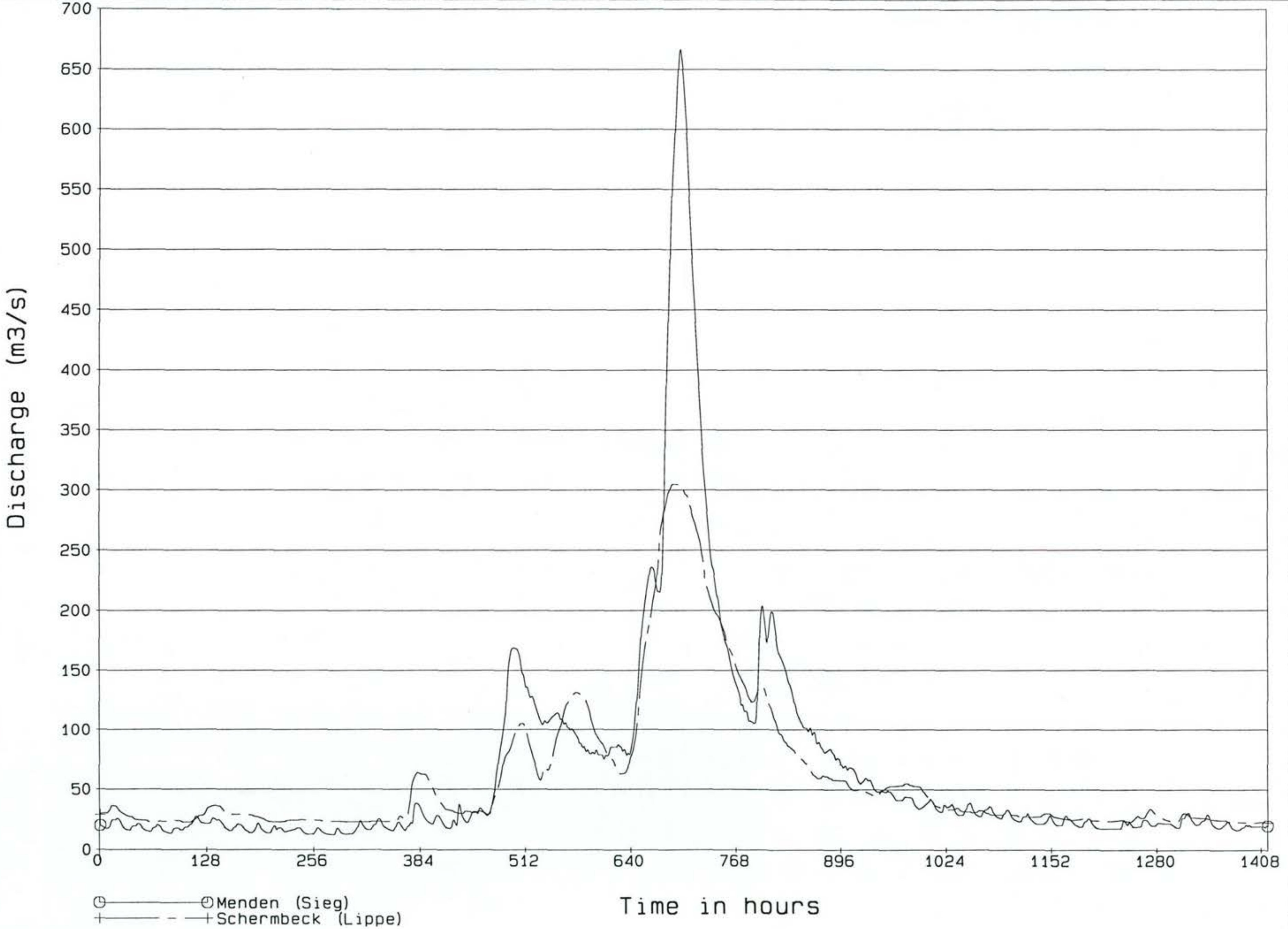
Hydrographs Sieg and Lippe
Stations Menden and Schermbeck
Period 5: 1/2/1984 - 29/2/1984



R3049

FIG. 2.14.2

Hydrographs Sieg and Lippe
Stations Menden and Schermbeck
Period 6: 1/5/1984 - 30/6/1984

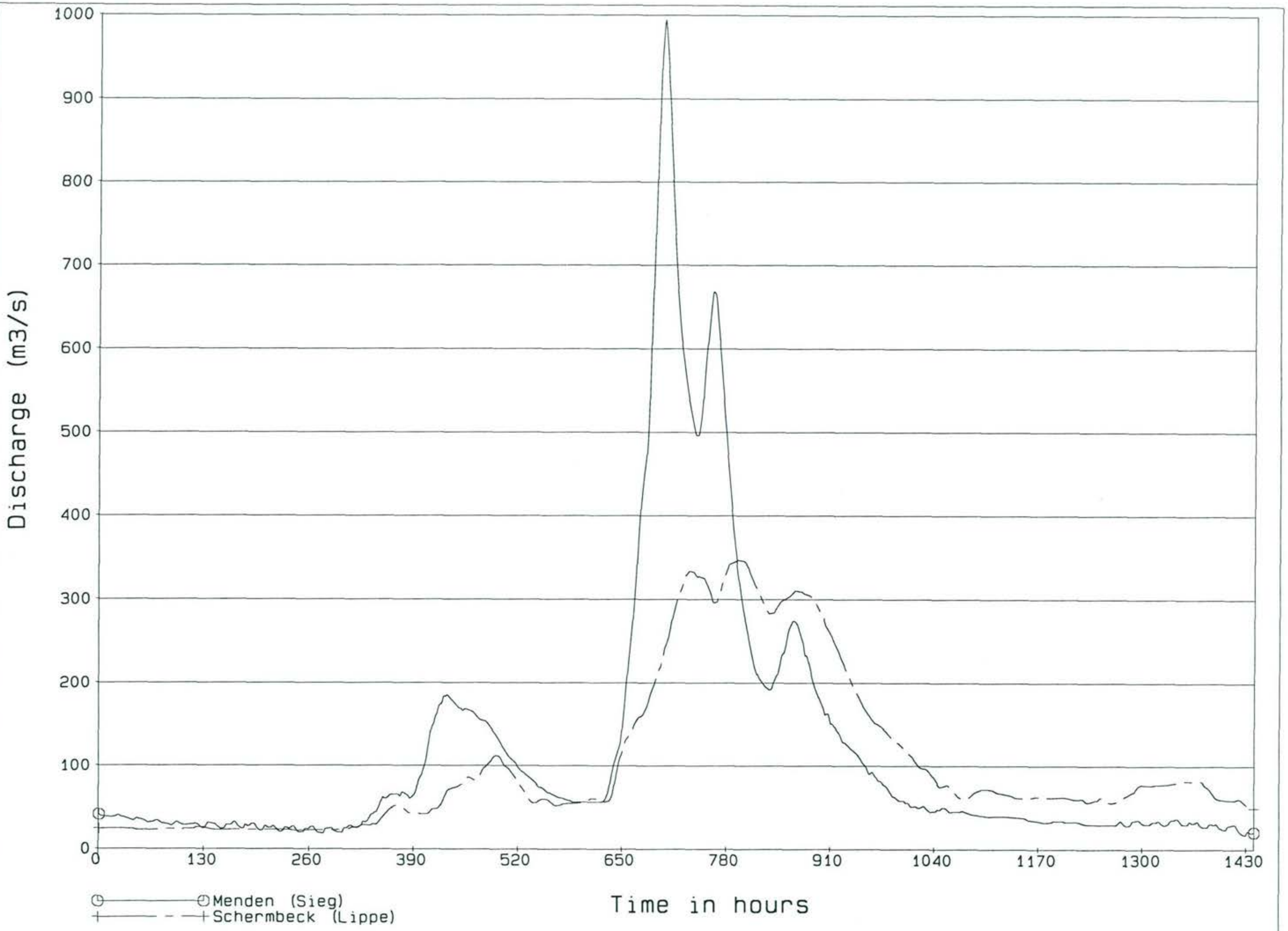


DELFT HYDRAULICS

R3049

FIG. 2.14.3

Hydrographs Sieg and Lippe
Stations Menden and Schermbeck
Period 8: 1/12/1986 - 31/1/1986



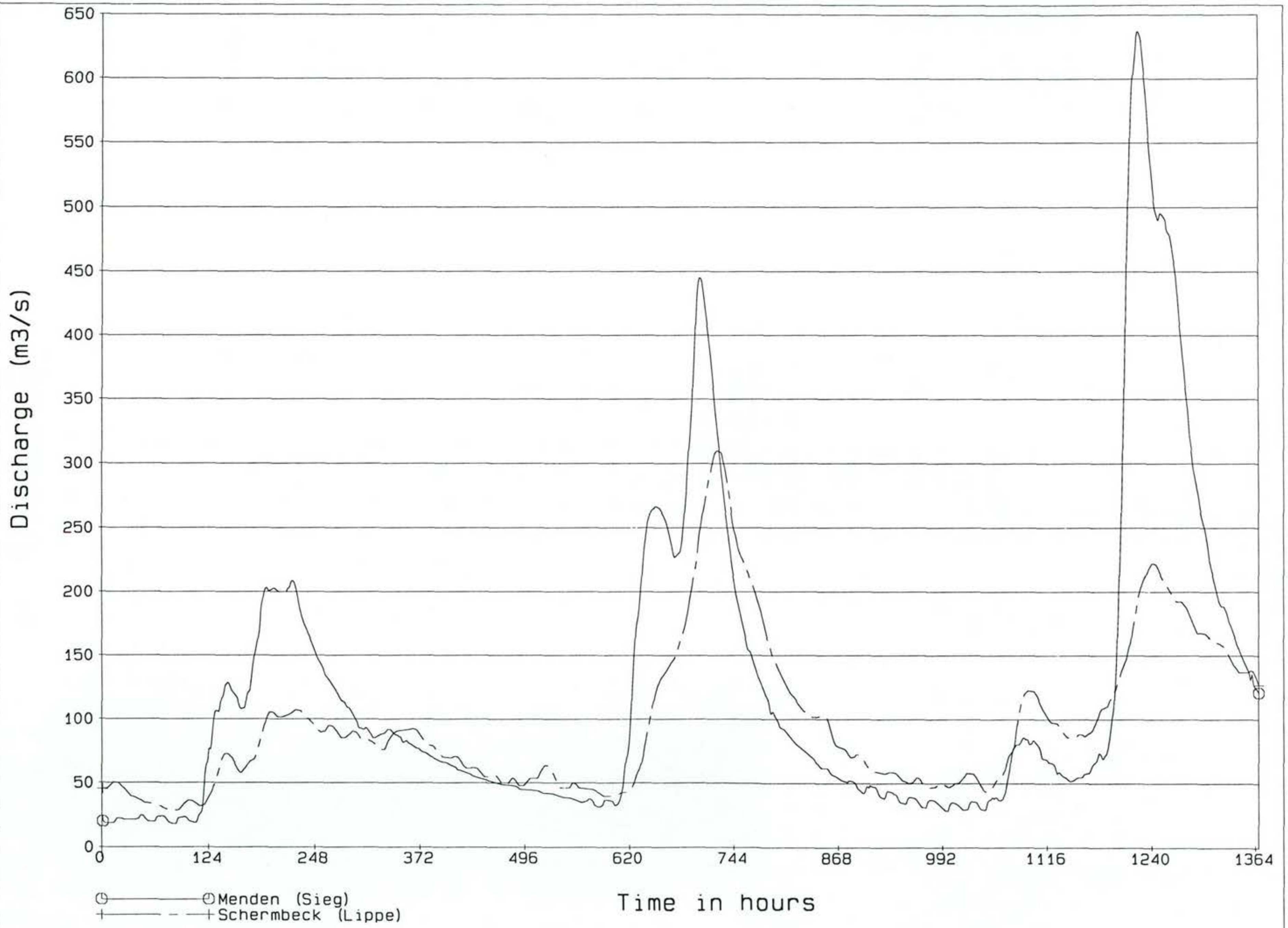
DELFT HYDRAULICS

R3049

FIG. 2.14.4

DELFT HYDRAULICS

Hydrographs Sieg and Lippe
Stations Menden and Schermbeck
Period 9: 1/2/1987 - 31/3/1987

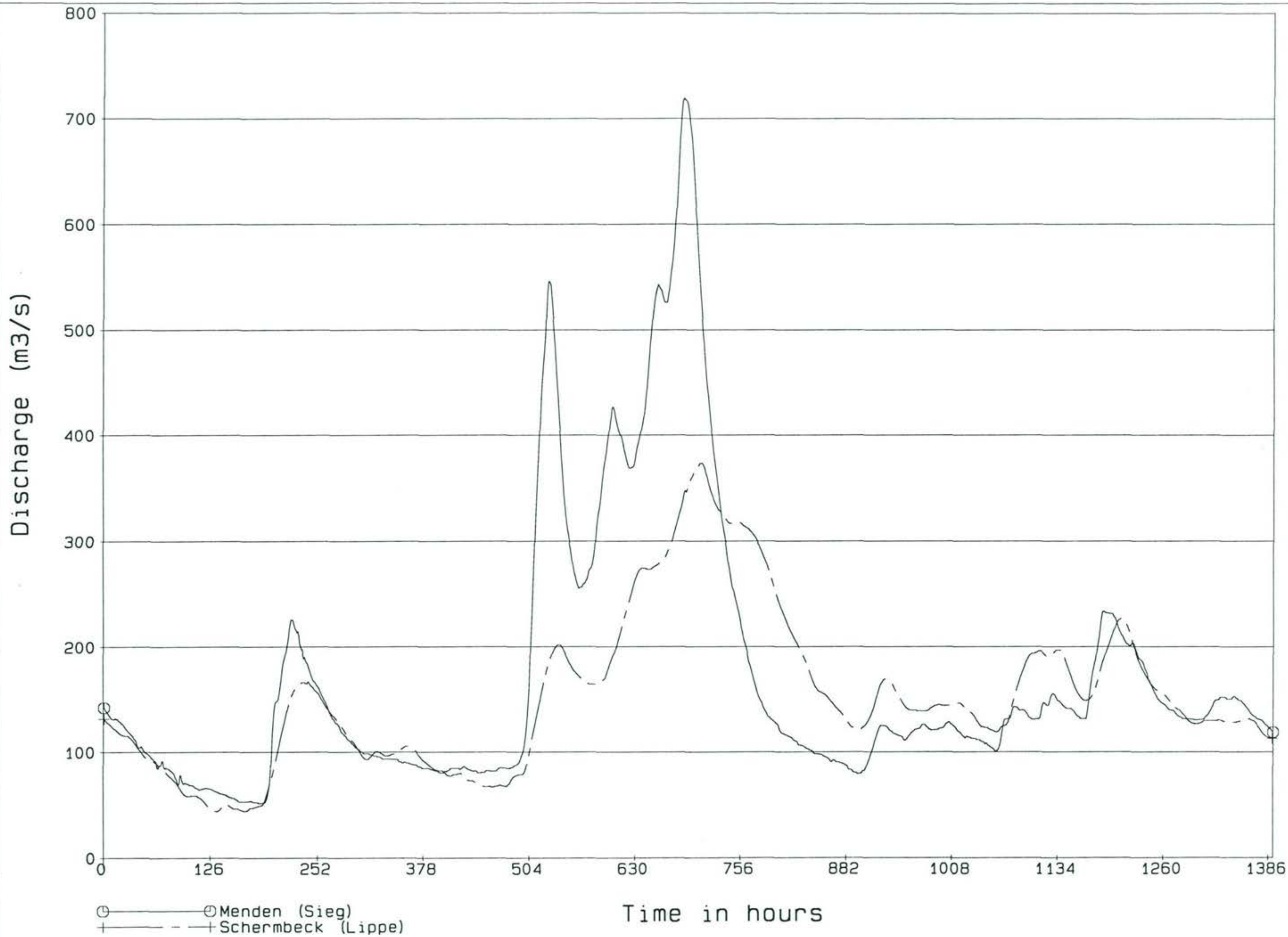


R3049

FIG. 2.14.5

DELFT HYDRAULICS

Hydrographs Sieg and Lippe
Stations Menden and Schermbeck
Period 14: 1/1/1995 - 31/1/1995



R3049

FIG. 2.14.6

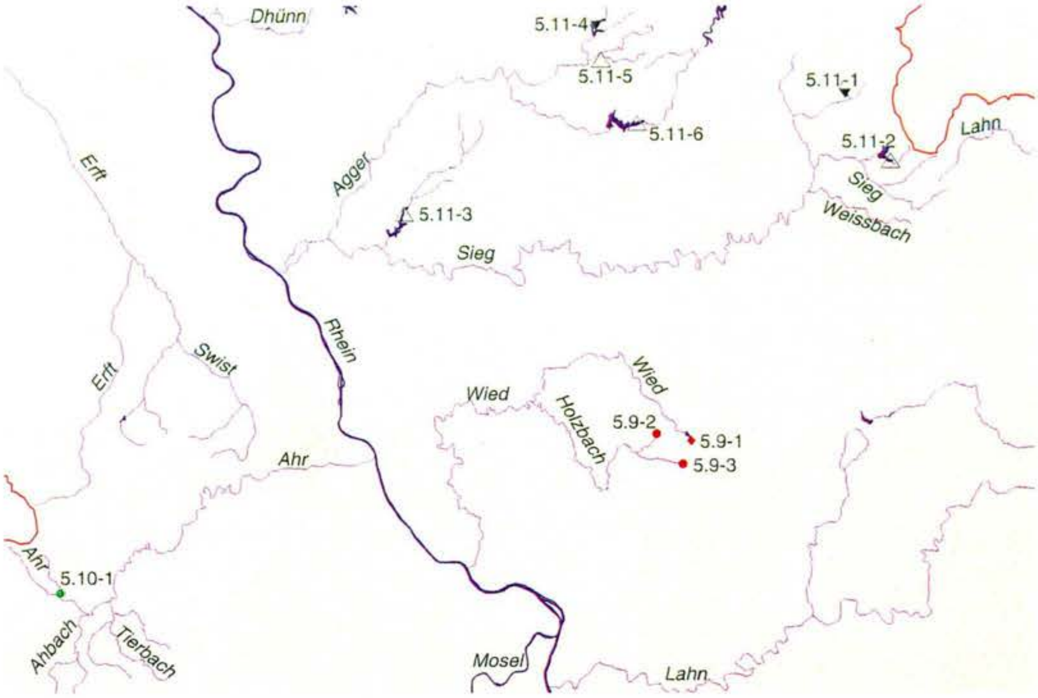


Fig. 2.15 Location of the reservoirs in the Sieg and Lippe basin

Figures of Chapter 3

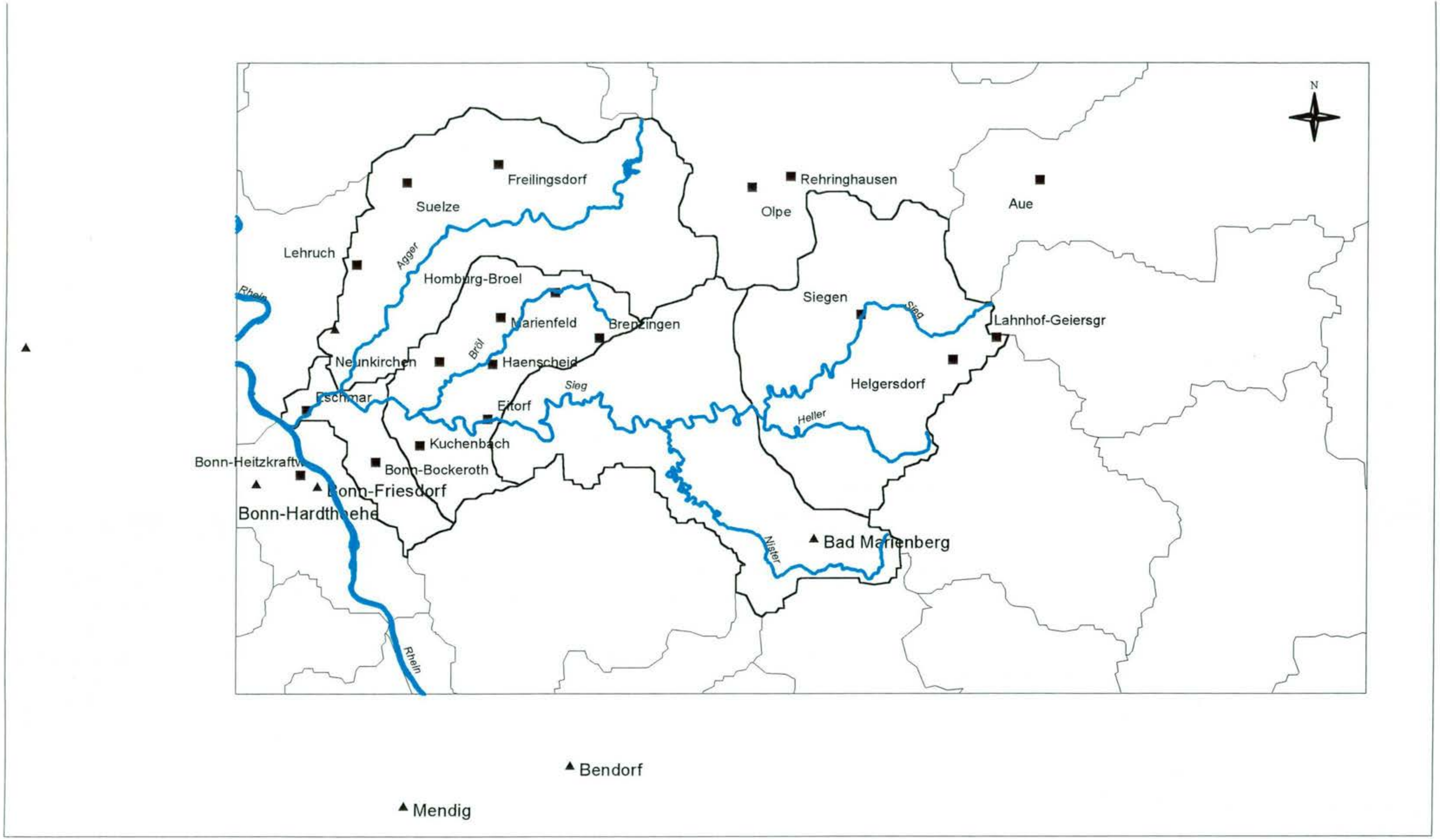


Fig 3.1 Sieg basin, location of LUA-NRW and DWD meterological stations

Legend:

Sieg: river Sieg

Eitorf: Discharge station Eitorf

▲ DWD synoptic stations

■ LUA-NRW meterological stations

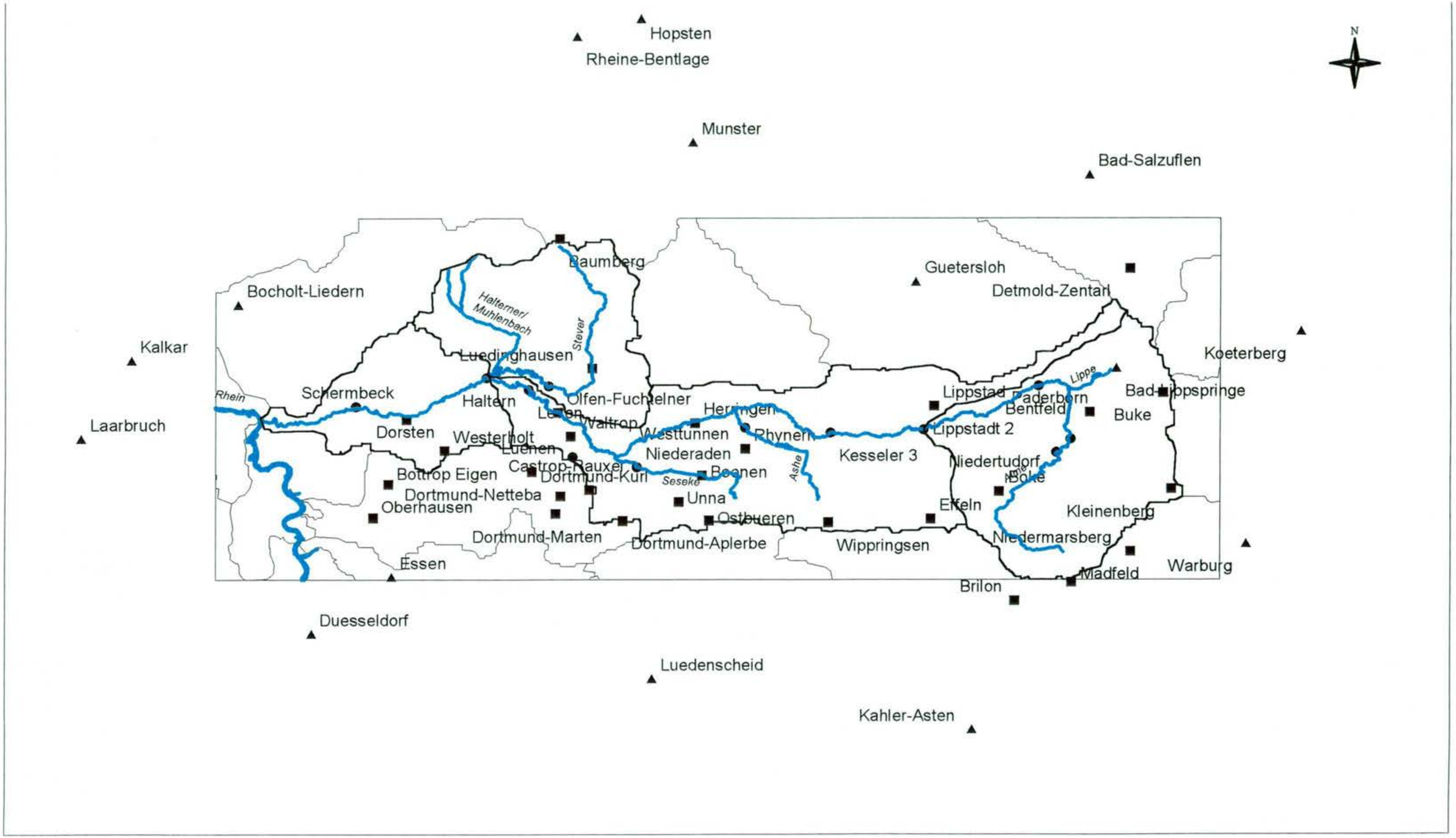


Fig 3.2 Lippe basin, locations of LUA-NRW and DWD meterological stations

Legend:

Sieg: river Sieg

Eitorf: Discharge station Eitorf

▲ DWD synoptic stations

■ LUA-NRW meterological stations

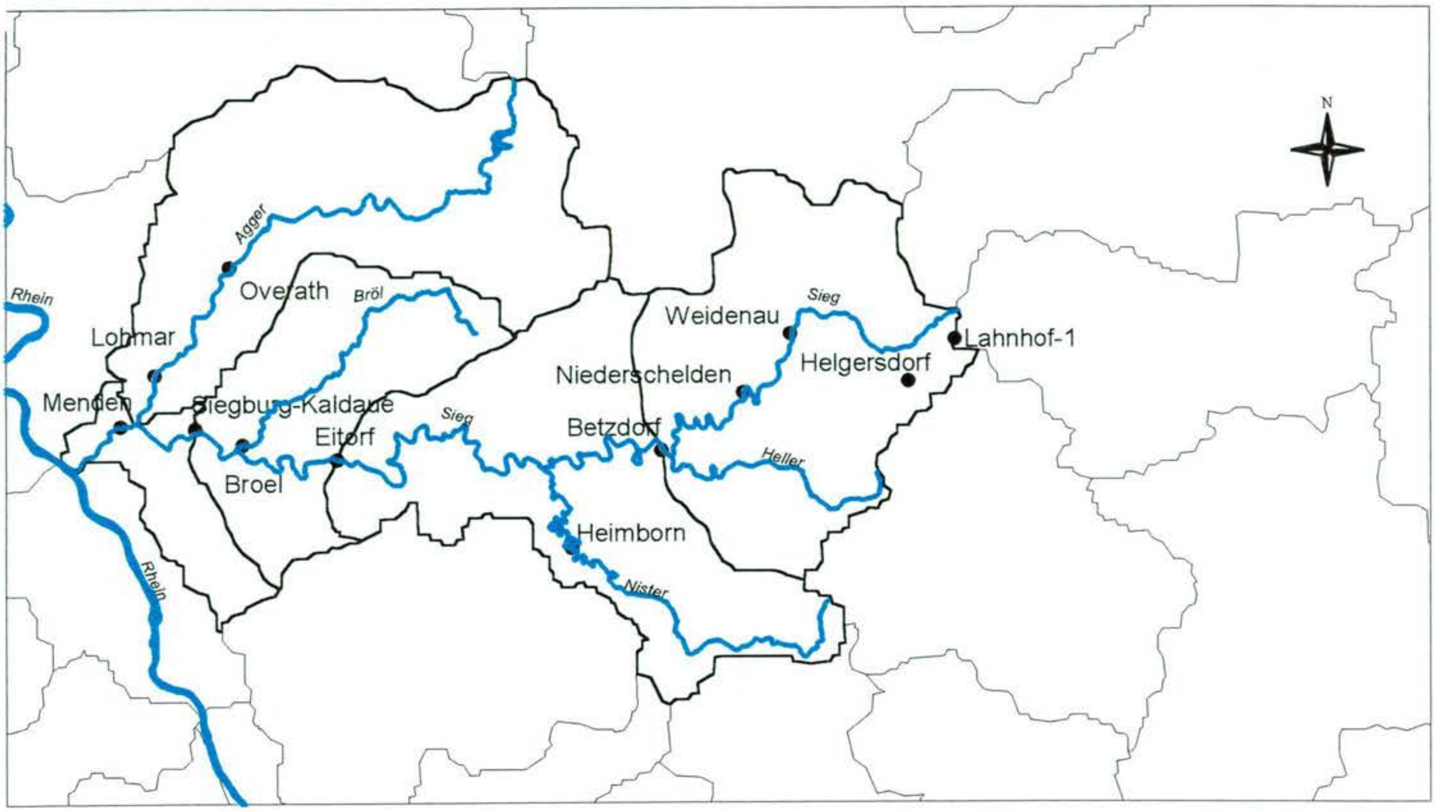


Fig 3.3 Sieg basin, location of rated river gauging stations

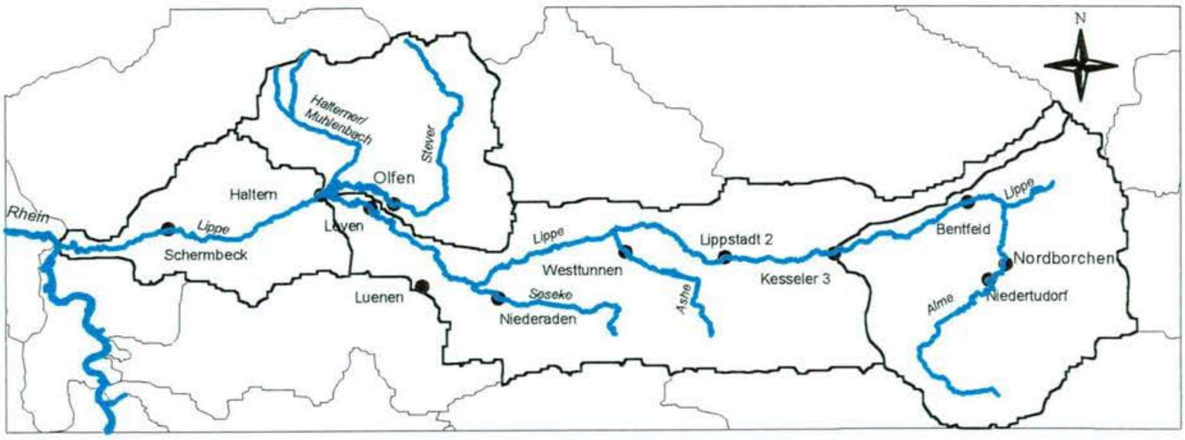


Fig 3.4 Lippe basin, locations of rated river gauging stations

Legend:
Sieg: river Sieg
Eitorf: Discharge station Eitorf

Figures of Chapter 4

DELFT HYDRAULICS

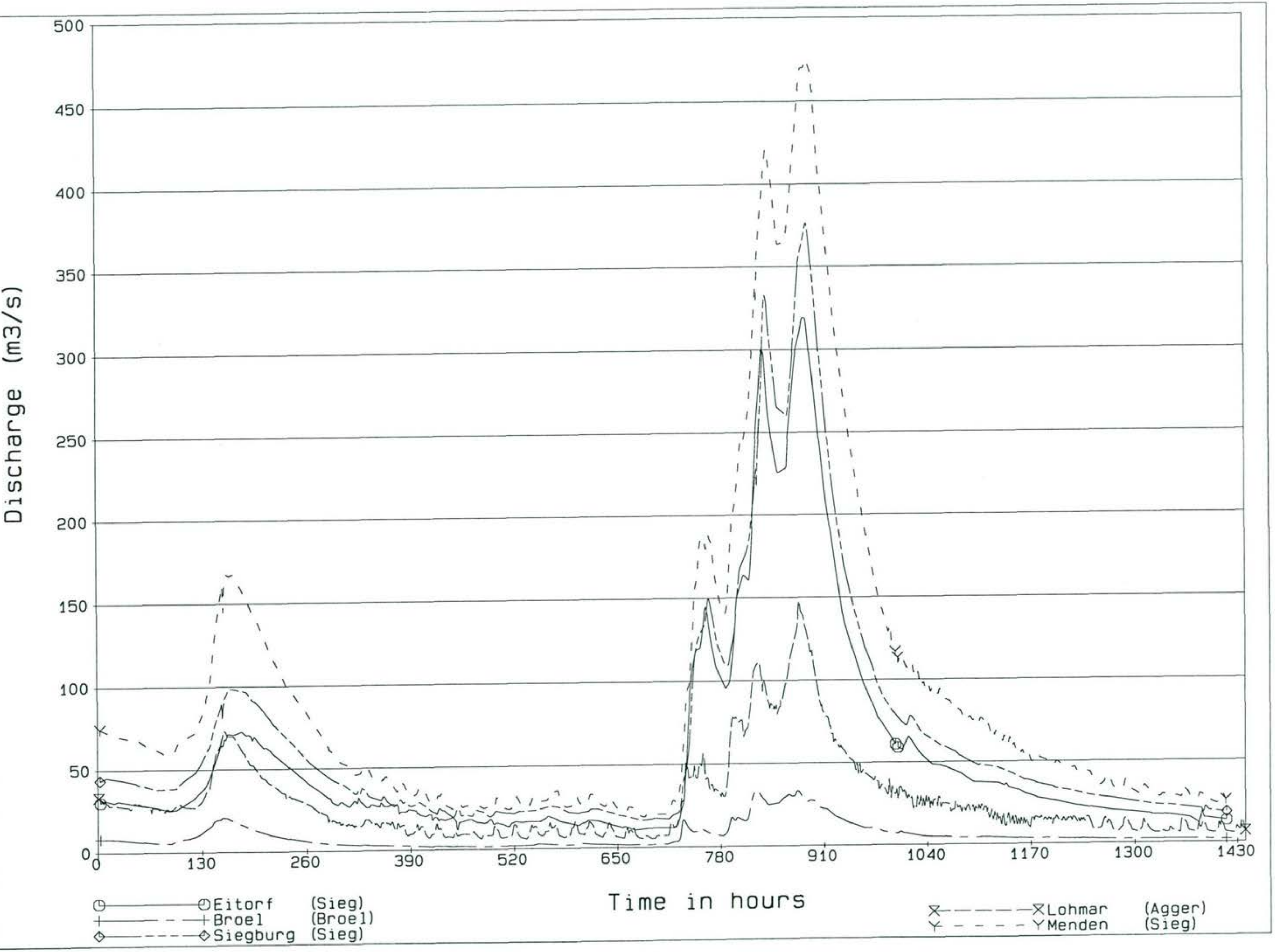
Hydrographs Sieg river and tributaries

Period 1: 1/1/1980 - 29/2/1980

Uncorrected

R3049

FIG. 4.1.1



Hydrographs Sieg river and tributaries

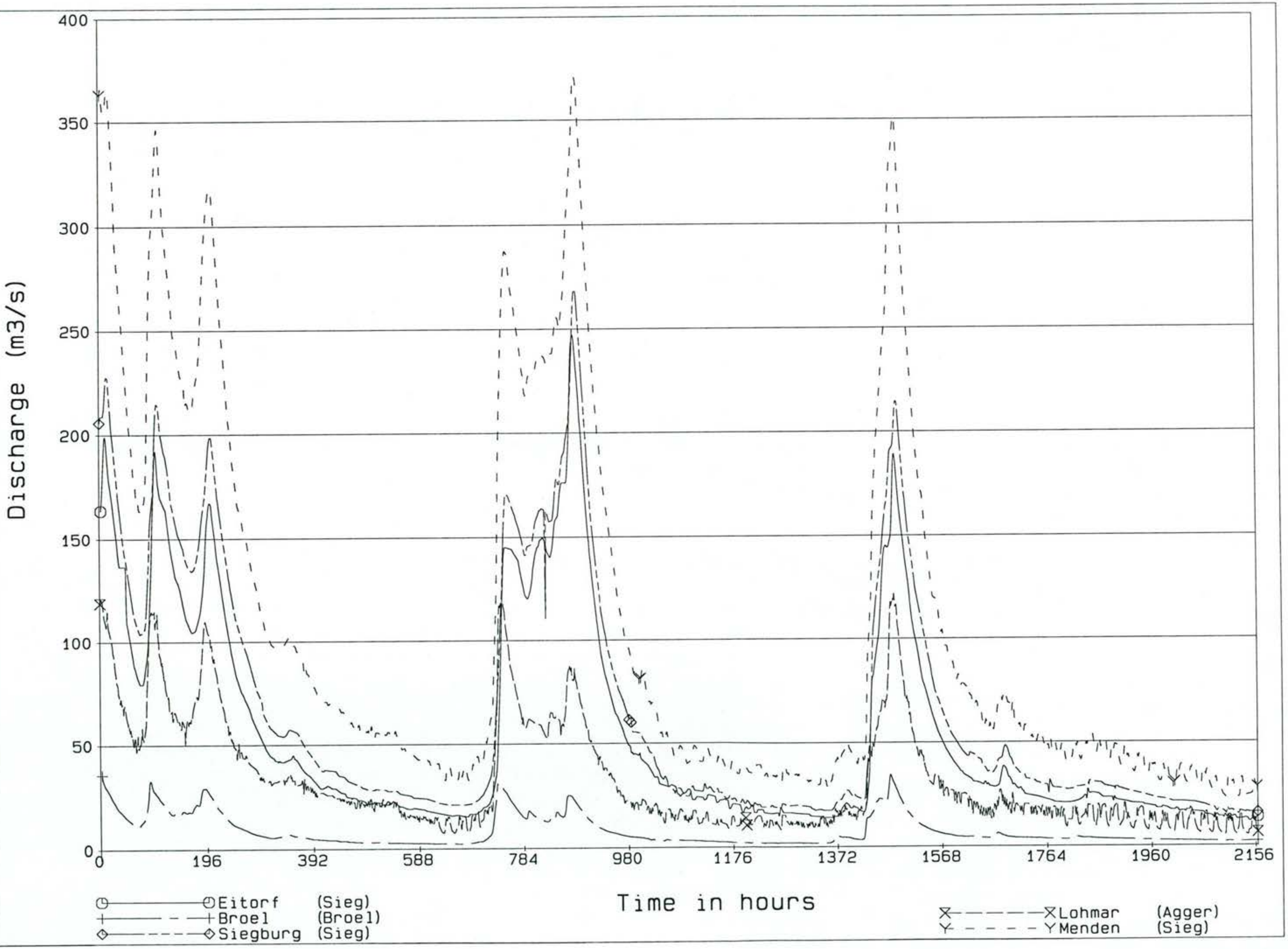
Period 2: 1/12/1981 - 28/2/1982

DELFT HYDRAULICS

Uncorrected

R3049

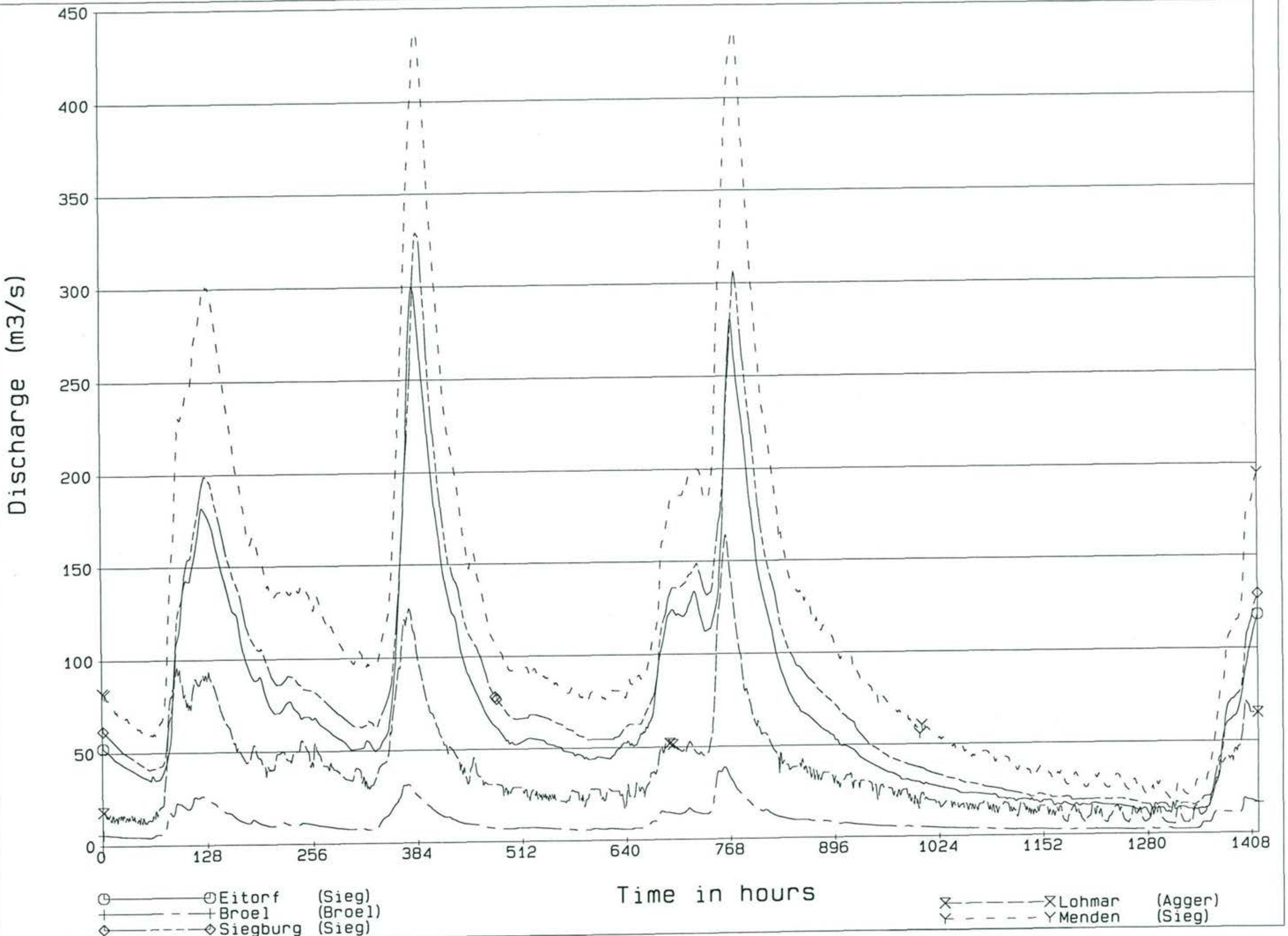
FIG. 4.1.2



DELFT HYDRAULICS

Period 3: 1/1/1983 - 31/2/1983

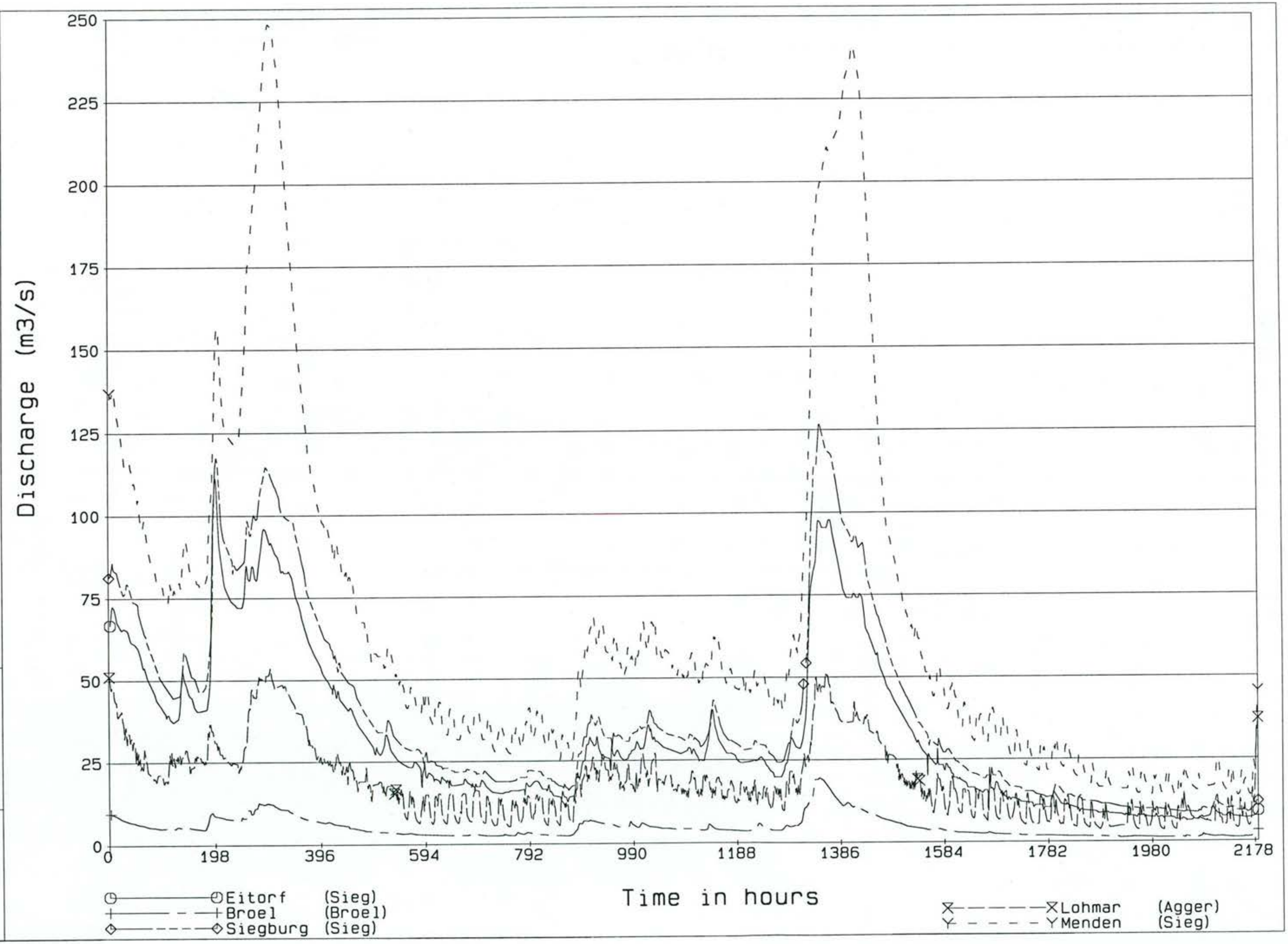
Hydrographs Sieg river and tributaries



R3049

Uncorrected

FIG. 4.1.3



Hydrographs Sieg river and tributaries

Period 4: 1/4/1983 - 30/6/1983

DELFT HYDRAULICS

R3049

Uncorrected

FIG. 4.1.4

Hydrographs Sieg river and tributaries

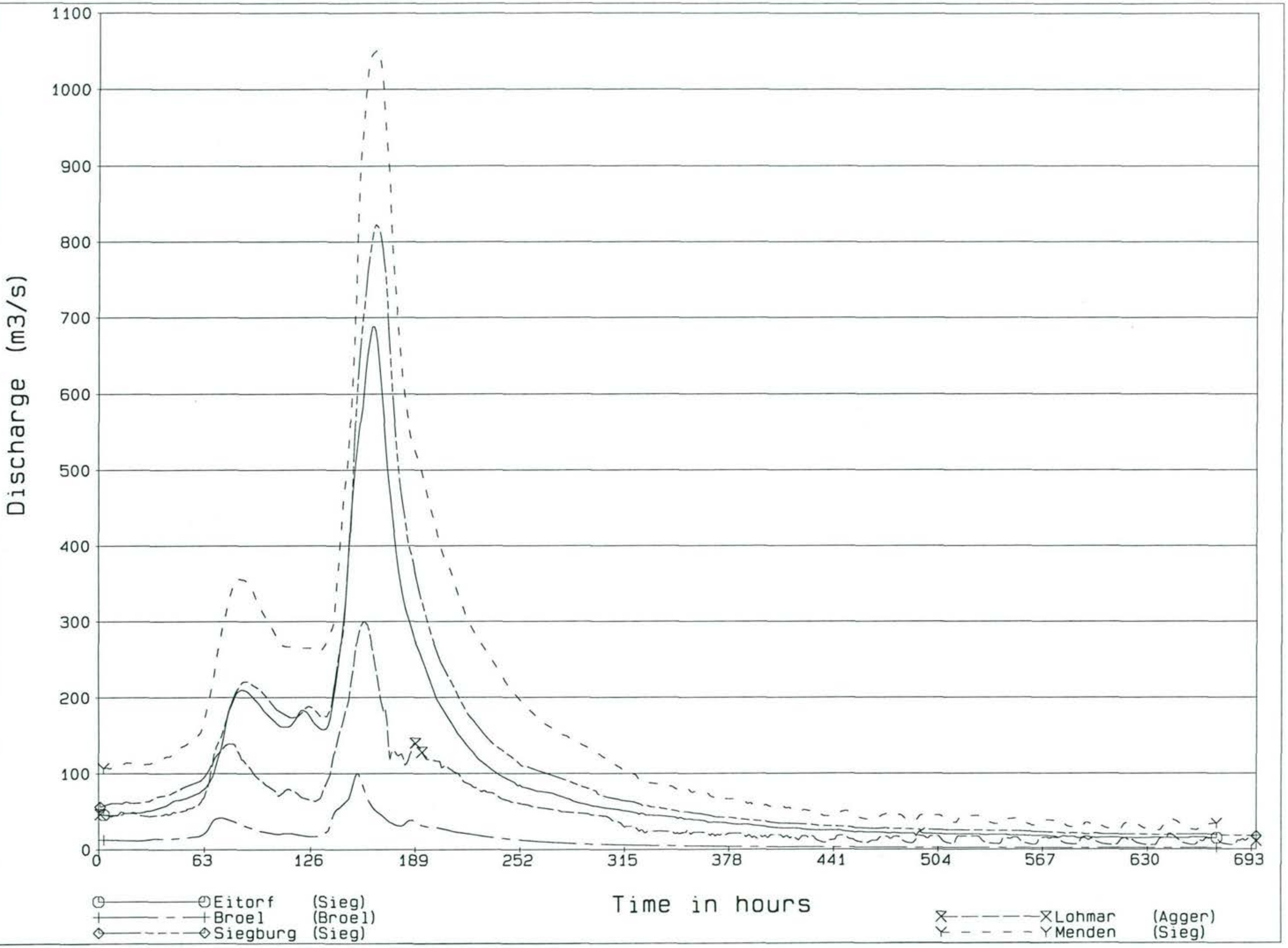
Period 5: 1/2/1984 - 29/2/1984

DELFT HYDRAULICS

Uncorrected

R3049

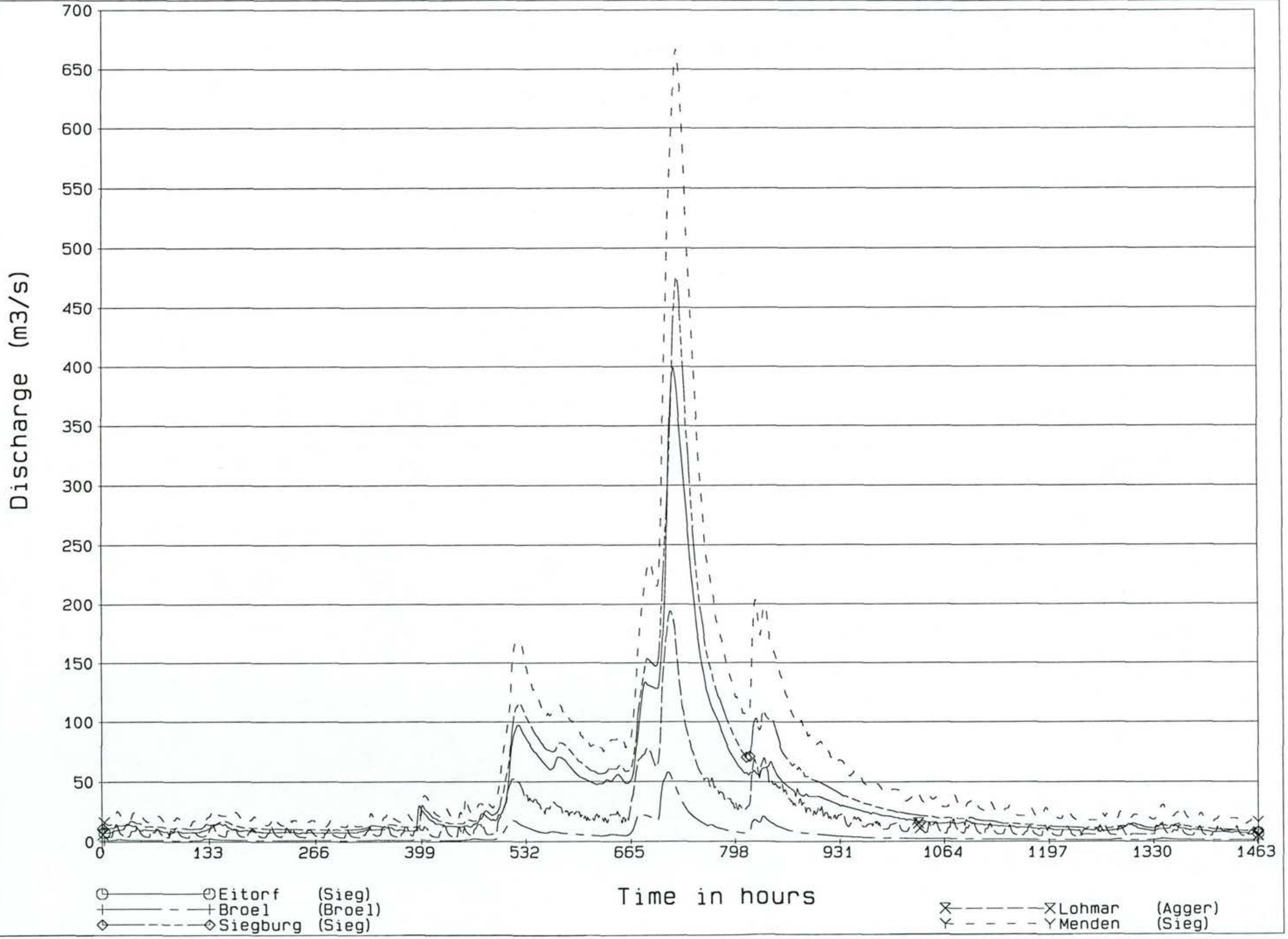
FIG. 4.1.5



DELFT HYDRAULICS

Hydrographs Sieg river and tributaries

Period 6: 1/5/1984 - 30/6/1984



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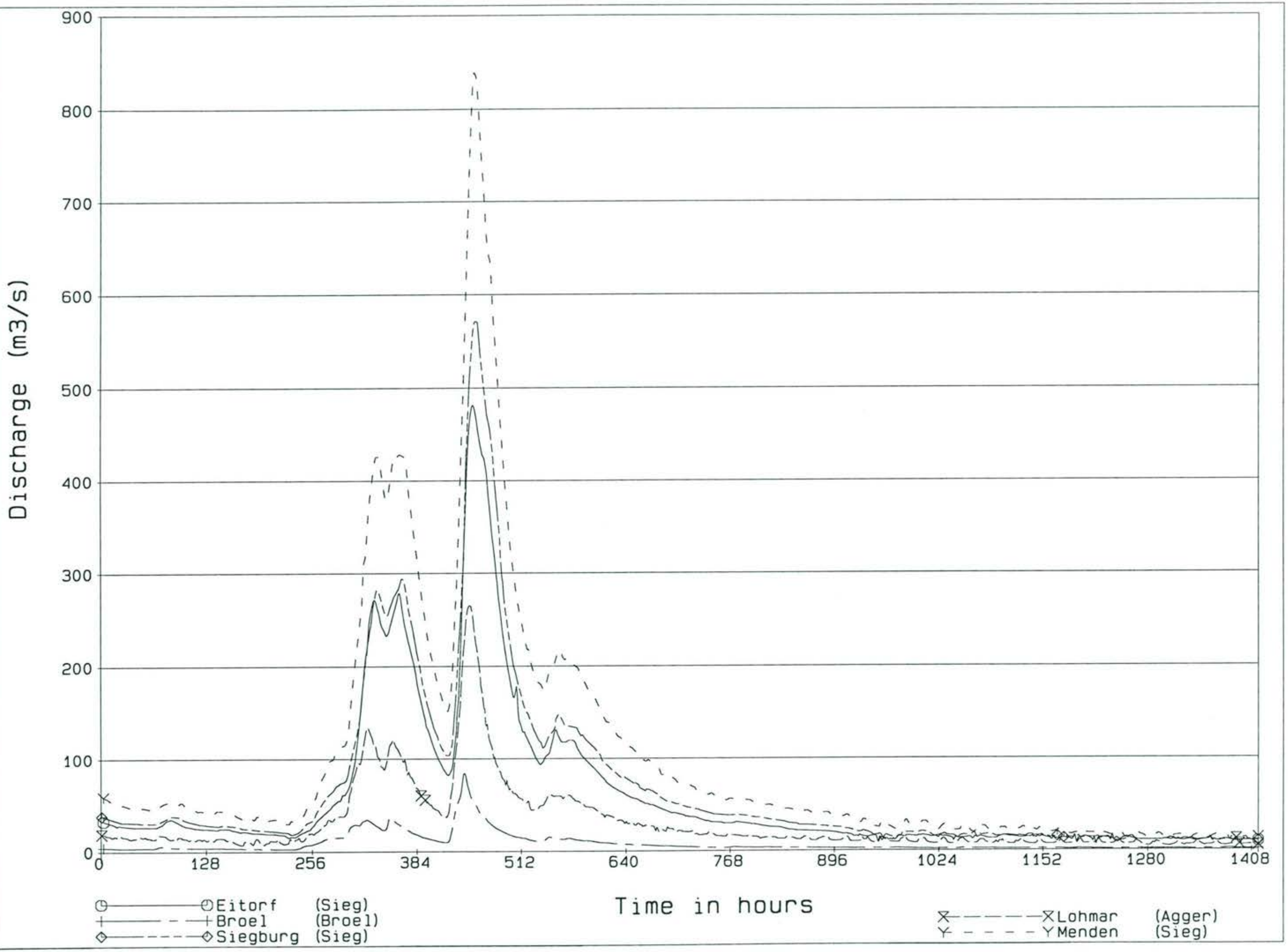
Uncorrected

FIG. 4.1.6

Hydrographs Sieg river and tributaries

Period 7: 1/1/1986 - 28/2/1986

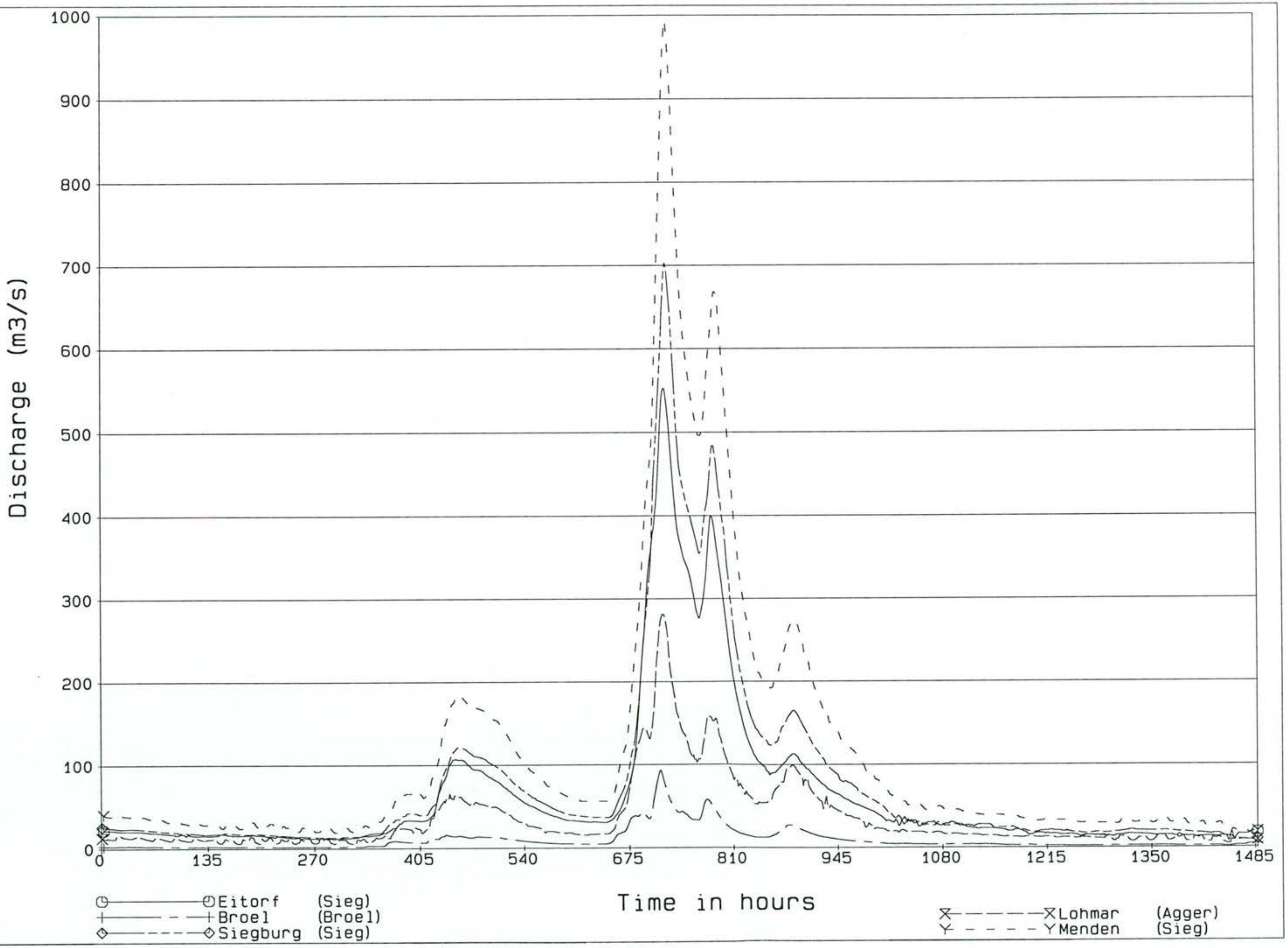


DELFT HYDRAULICS

Uncorrected

R3049

FIG. 4.1.7



Hydrographs Sieg river and tributaries

Period 8: 1/12/1986 - 31/1/1987

DELFT HYDRAULICS

Uncorrected

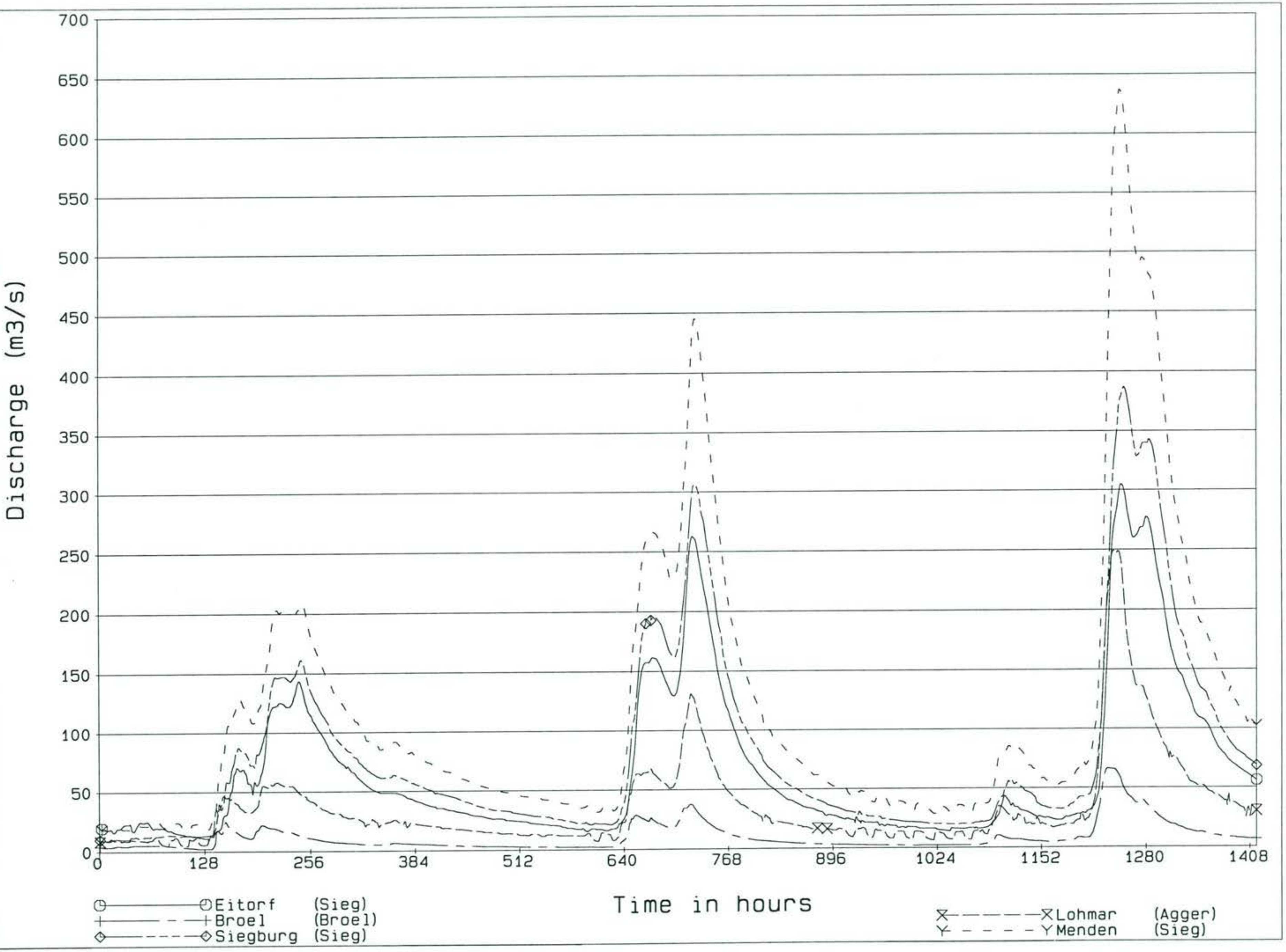
R3049

FIG. 4.1.8

DELFT HYDRAULICS

Hydrographs Sieg river and tributaries

Period 9: 1/2/1987 - 31/3/1987



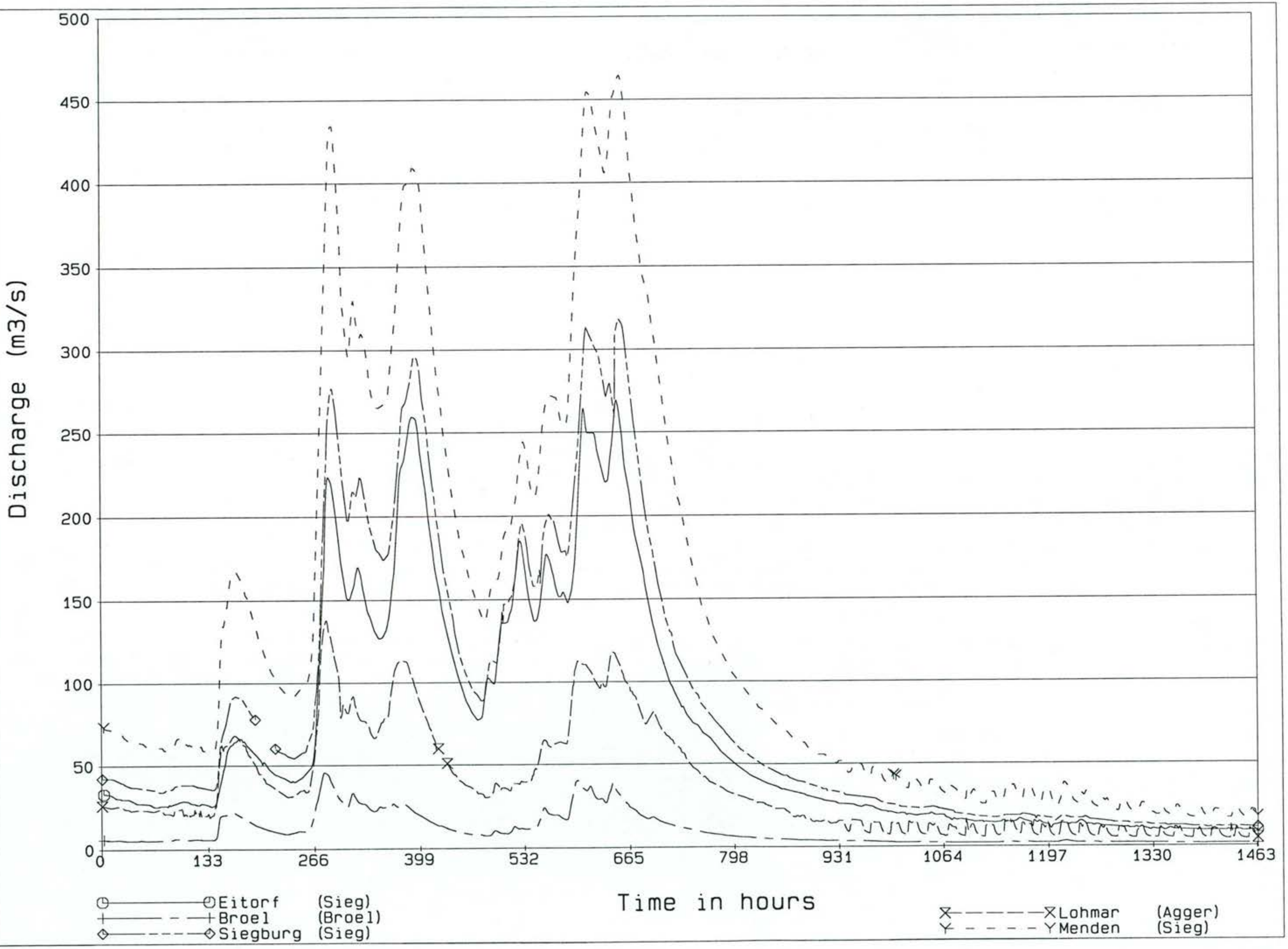
Uncorrected

R3049

FIG. 4.1.9

DELFT HYDRAULICS

Hydrographs Sieg river and tributaries
Period 10: 1/3/1988 - 30/4/1988



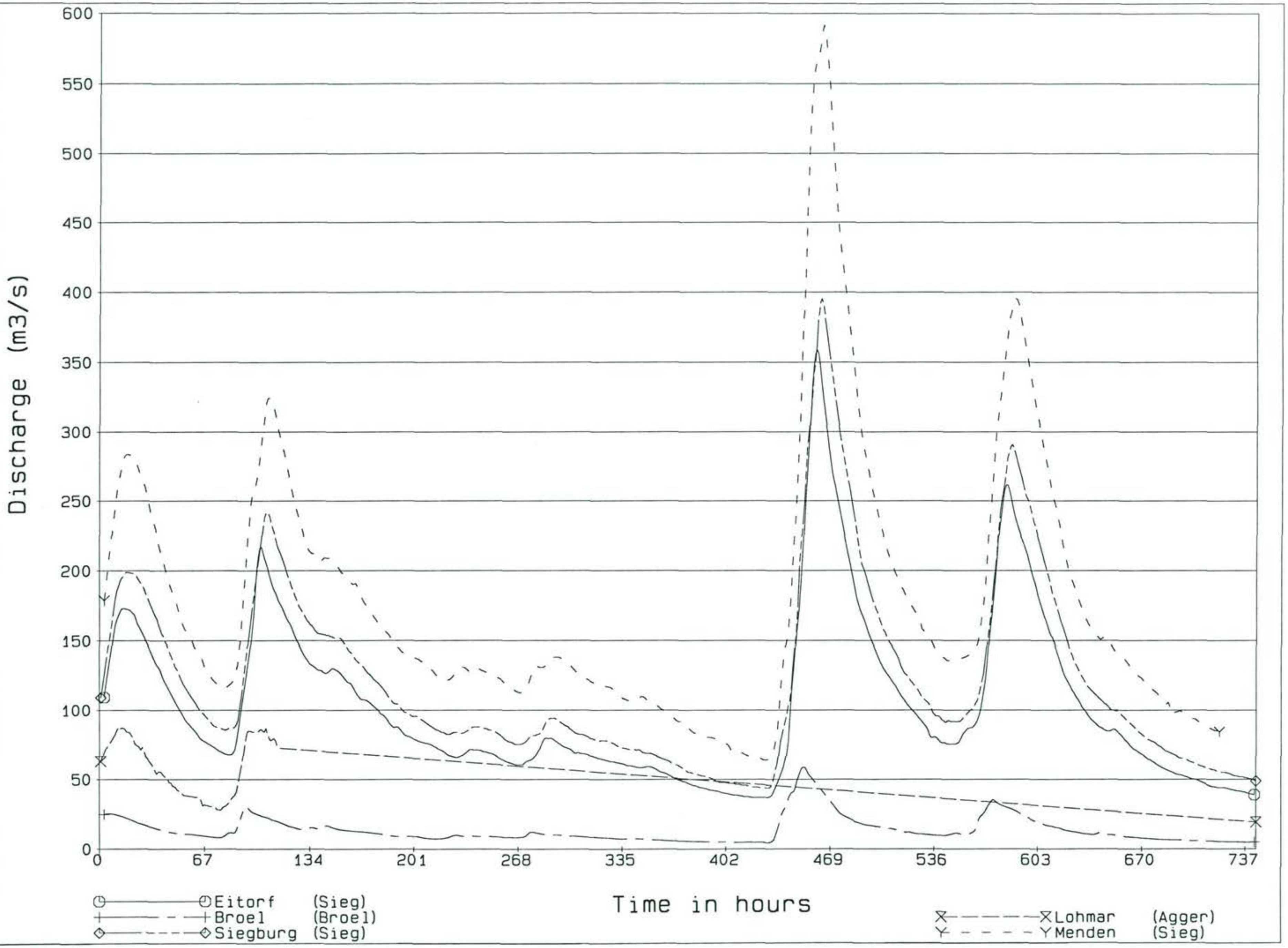
R3049

Uncorrected

FIG. 4.1.10

Hydrographs Sieg river and tributaries

Period 11: 1/12/1988 - 31/12/1988



DELFT HYDRAULICS

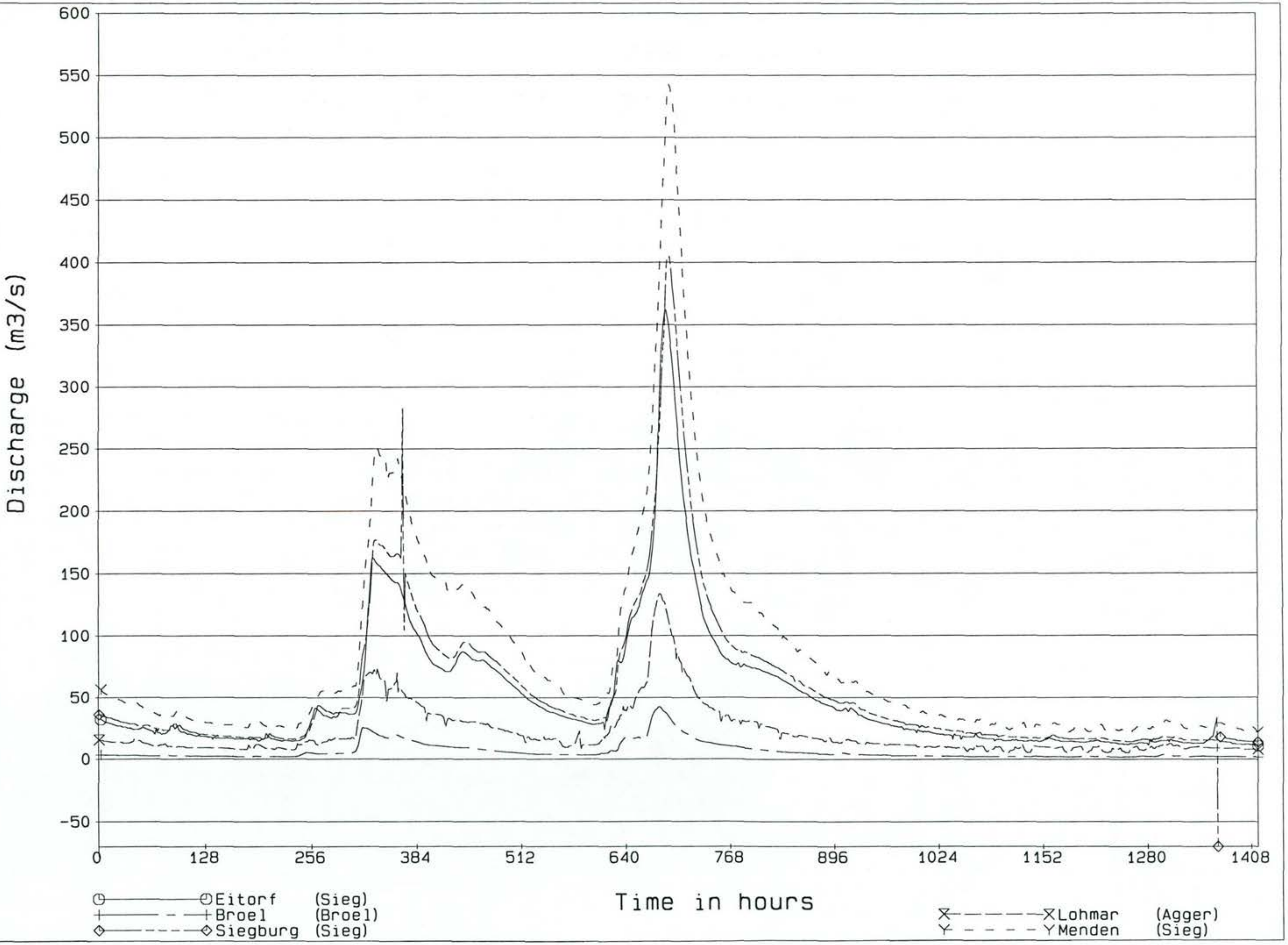
R3049

Uncorrected

FIG. 4.1.11

Hydrographs Sieg river and tributaries

Period 12: 1/2/1990 - 31/3/1990



DELFT HYDRAULICS

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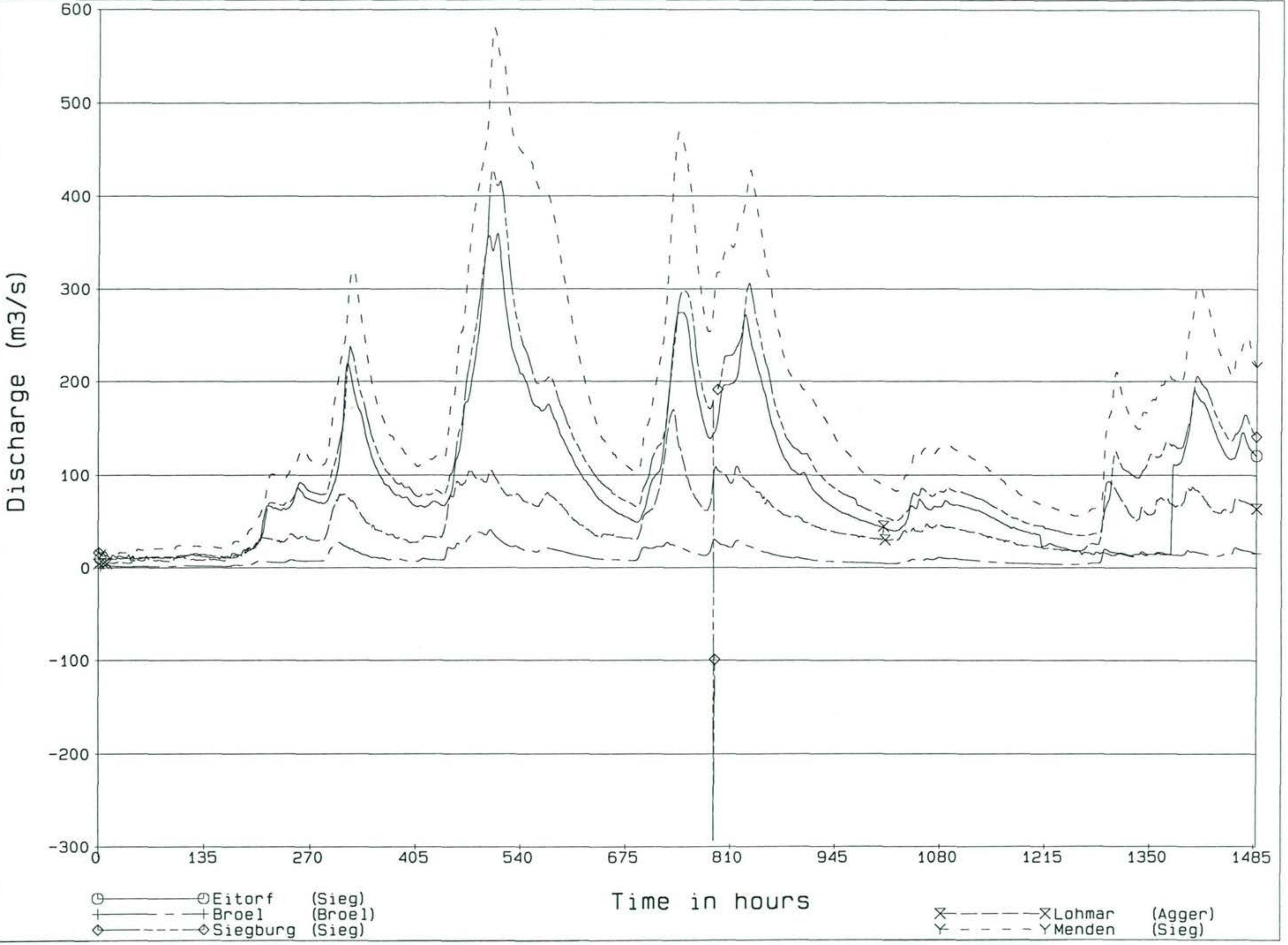
Uncorrected

FIG. 4.1.12

DELFT HYDRAULICS

Hydrographs Sieg river and tributaries

Period 13: 1/12/1993 - 31/1/1994



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Uncorrected

FIG. 4.1.13

Hydrographs Sieg river and tributaries

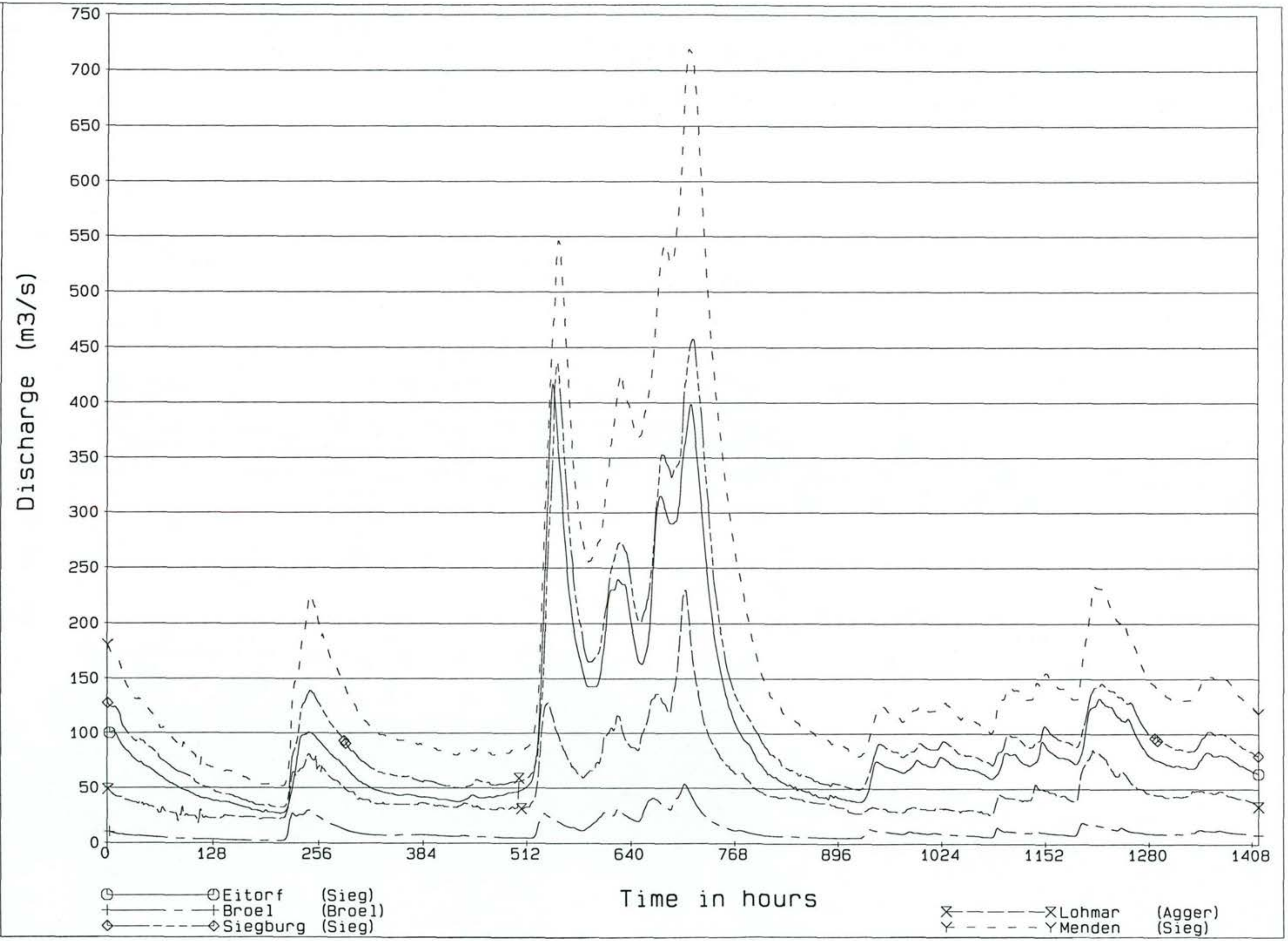
Period 14: 1/1/1995 - 28/2/1995

DELFT HYDRAULICS

R3049

Uncorrected

FIG. 4.1.14



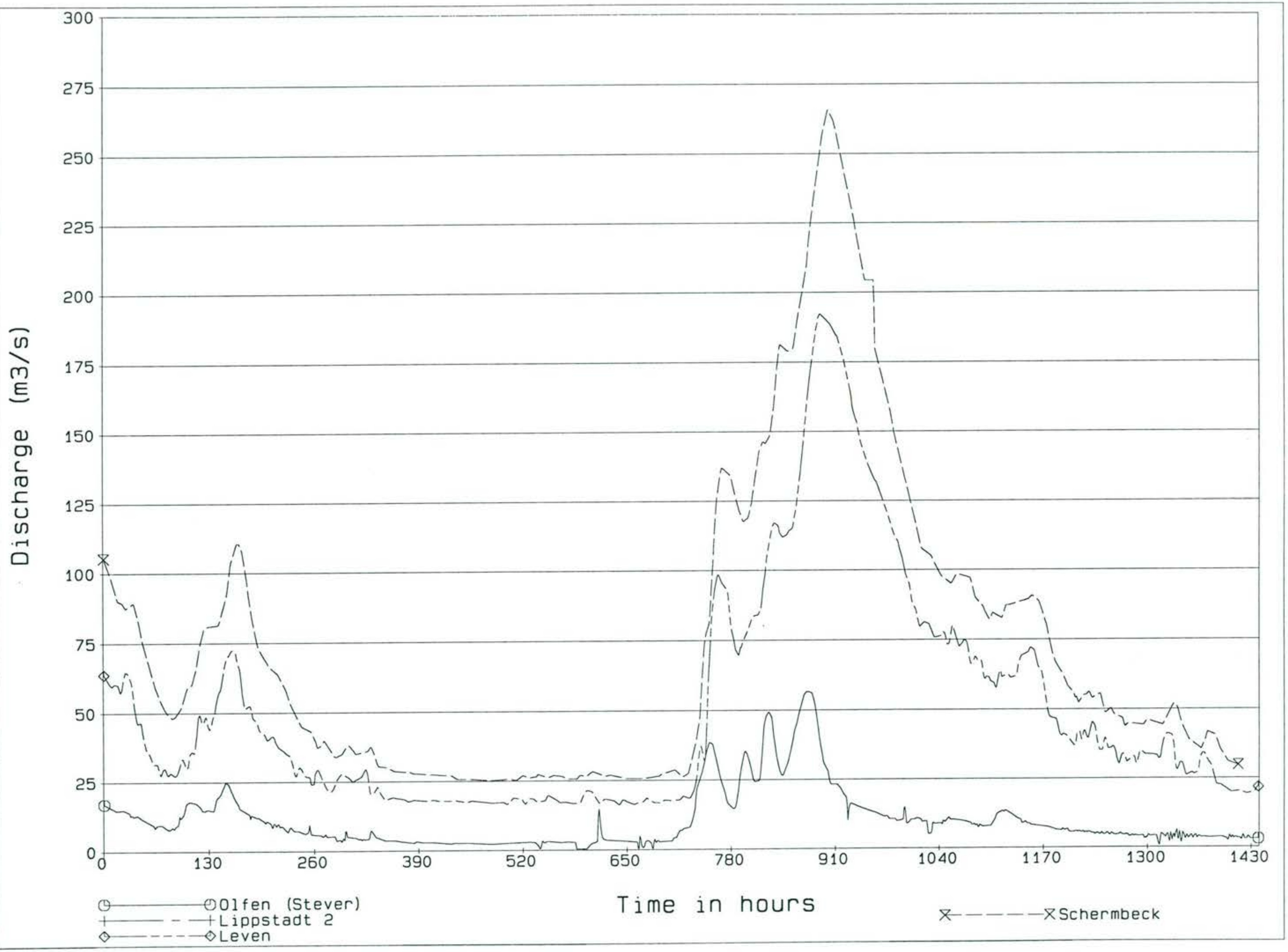
DELFT HYDRAULICS

Period 1: 1/1/1980 - 29/2/1980

Hydrographs Lippe river and tributary

R3049

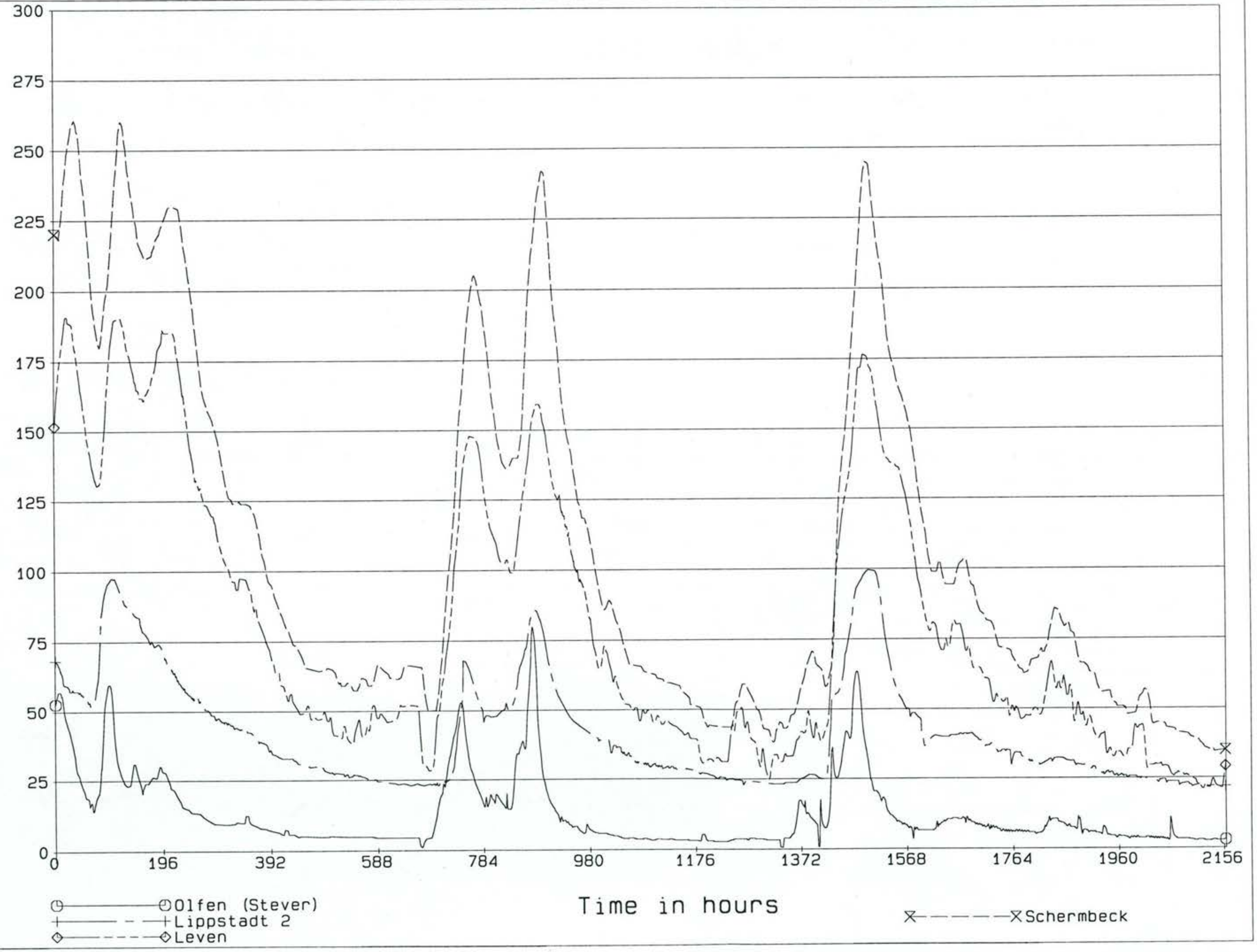
FIG. 4.2.1



DELFT HYDRAULICS

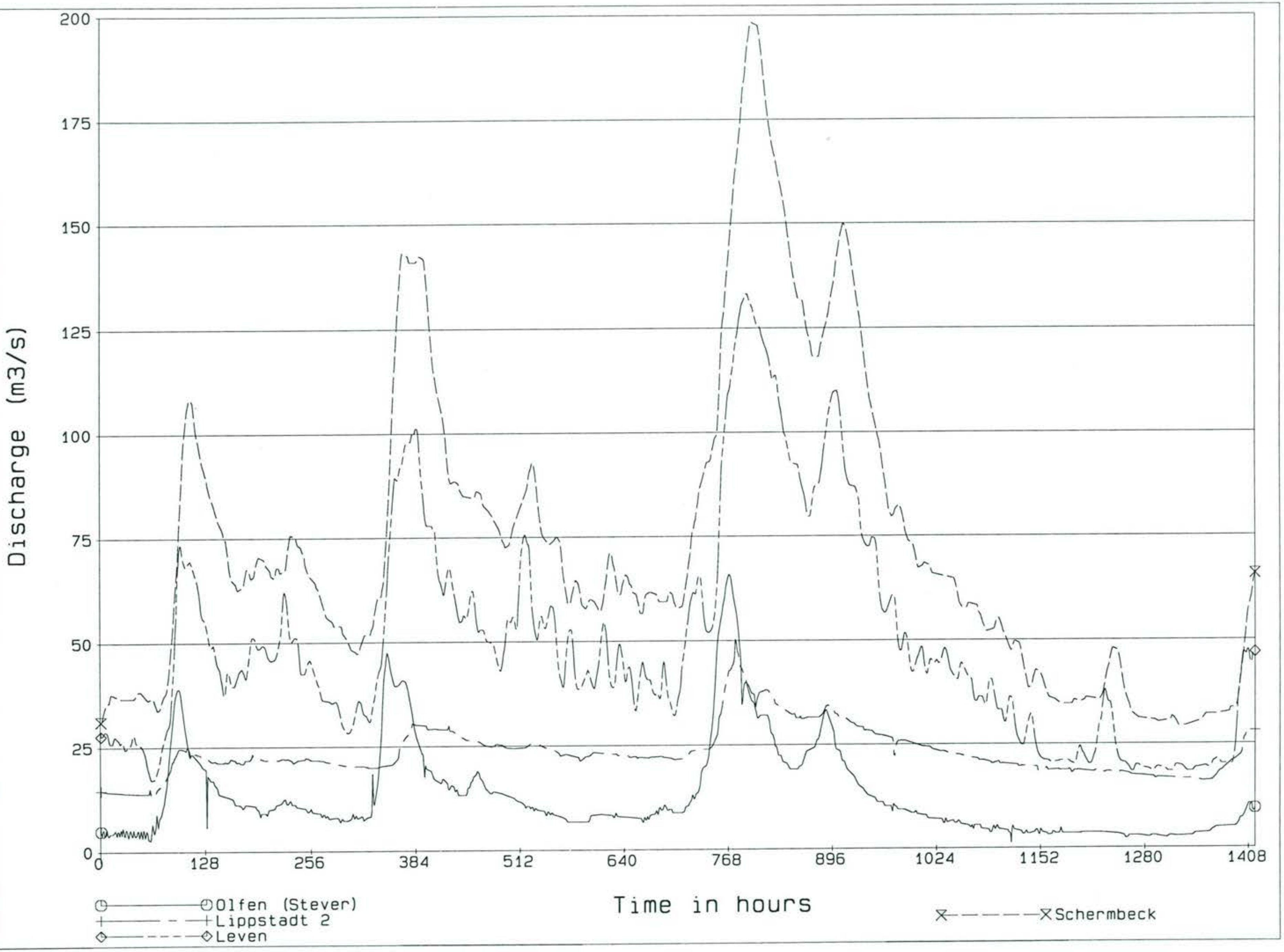
Hydrographs Lippe river and tributary

Period 2: 1/12/1981 - 28/2/1982



R3049

FIG. 4.2.2



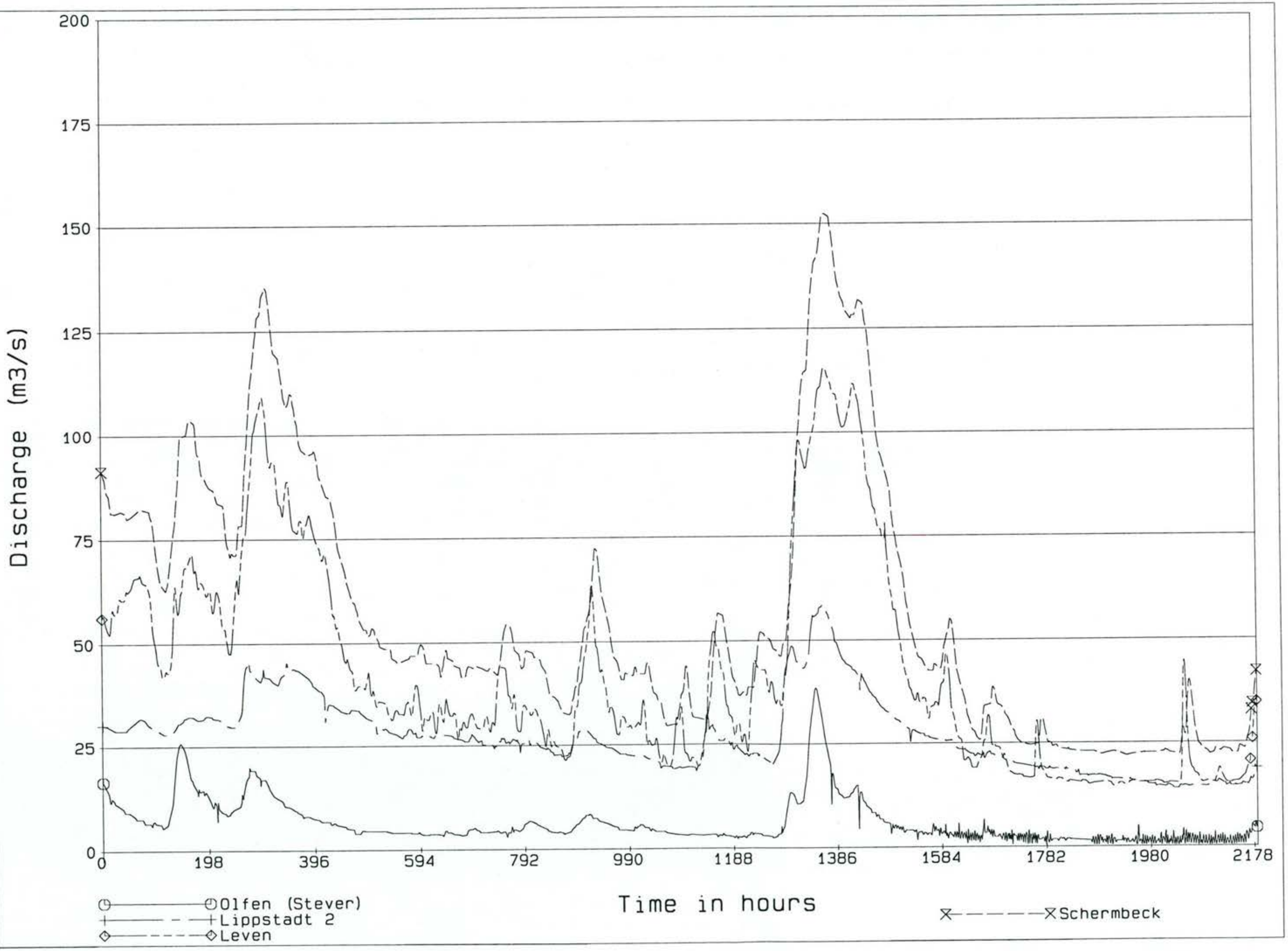
Hydrographs Lippe river and tributary

Period 3: 1/1/1983 - 28/2/1983

DELFT HYDRAULICS

R3049

FIG. 4.2.3



Hydrographs Lippe river and tributary

Period 4: 1/4/1983 - 30/6/1983

DELFT HYDRAULICS

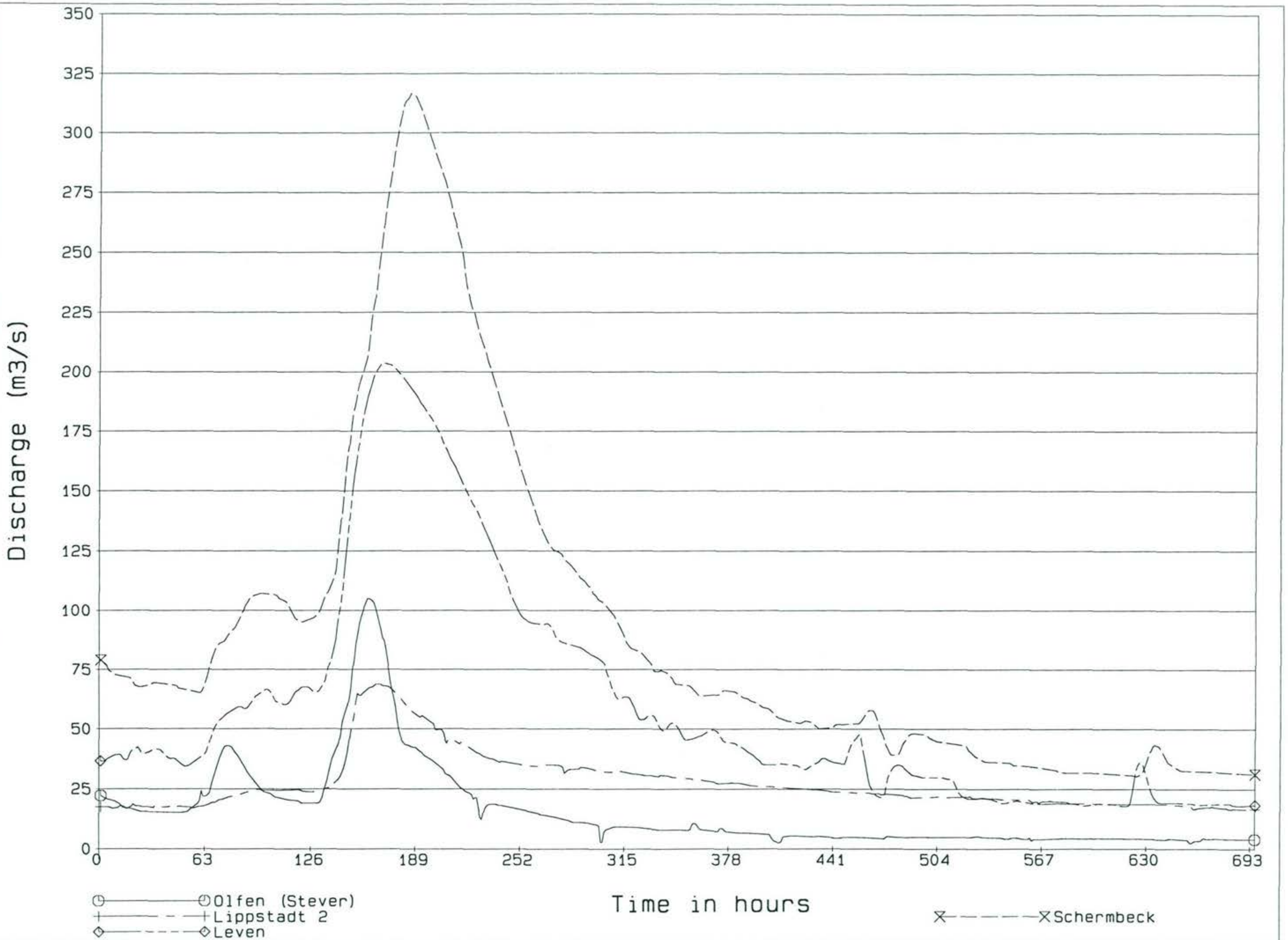
R3049

FIG. 4.2.4

DELFT HYDRAULICS

Hydrographs Lippe river and tributary

Period 5: 1/2/1984 - 29/2/1984



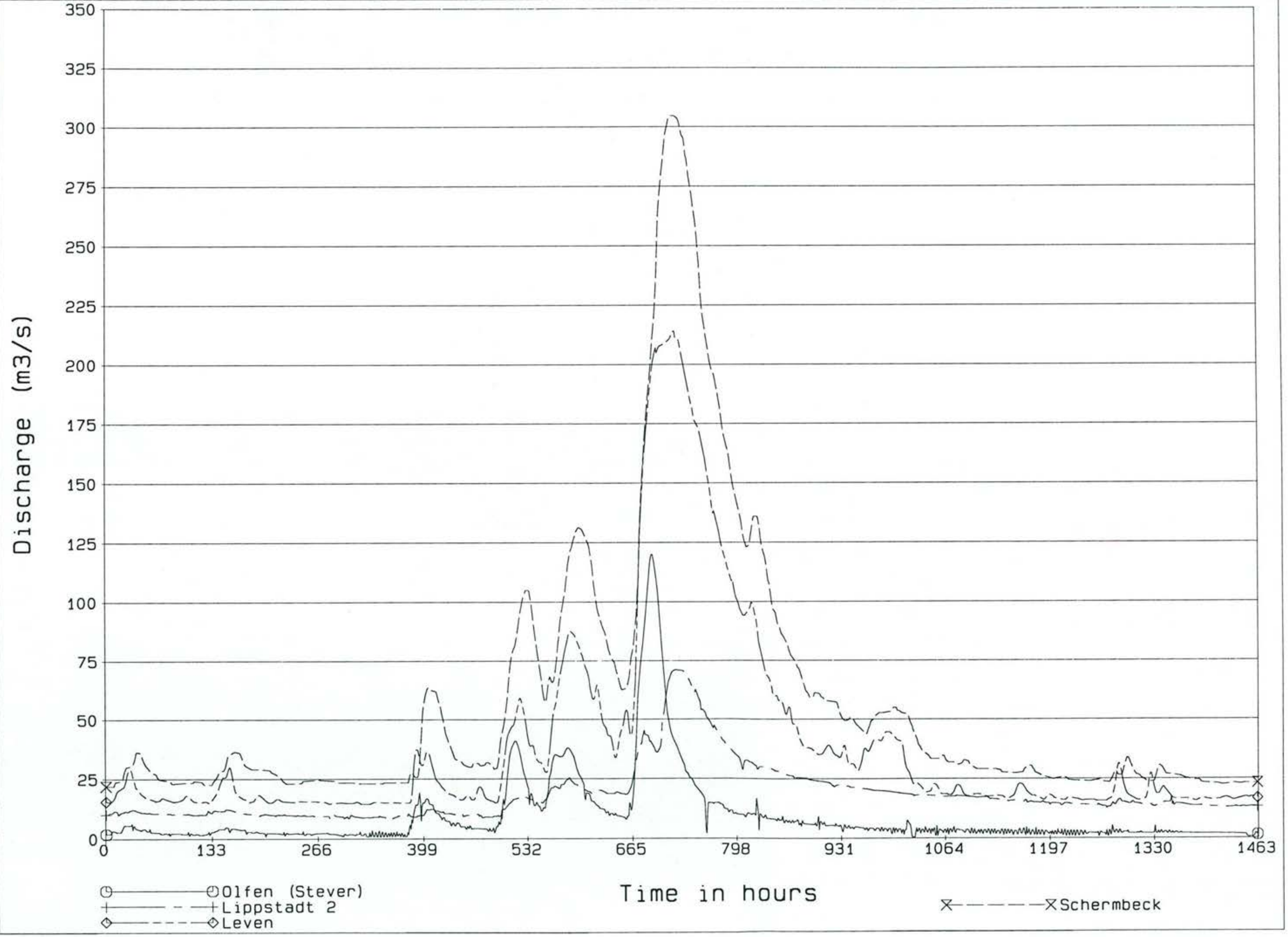
R3049

FIG. 4.2.5

DELFT HYDRAULICS

Hydrographs Lippe river and tributary

Period 6: 1/5/1984 - 30/6/1984



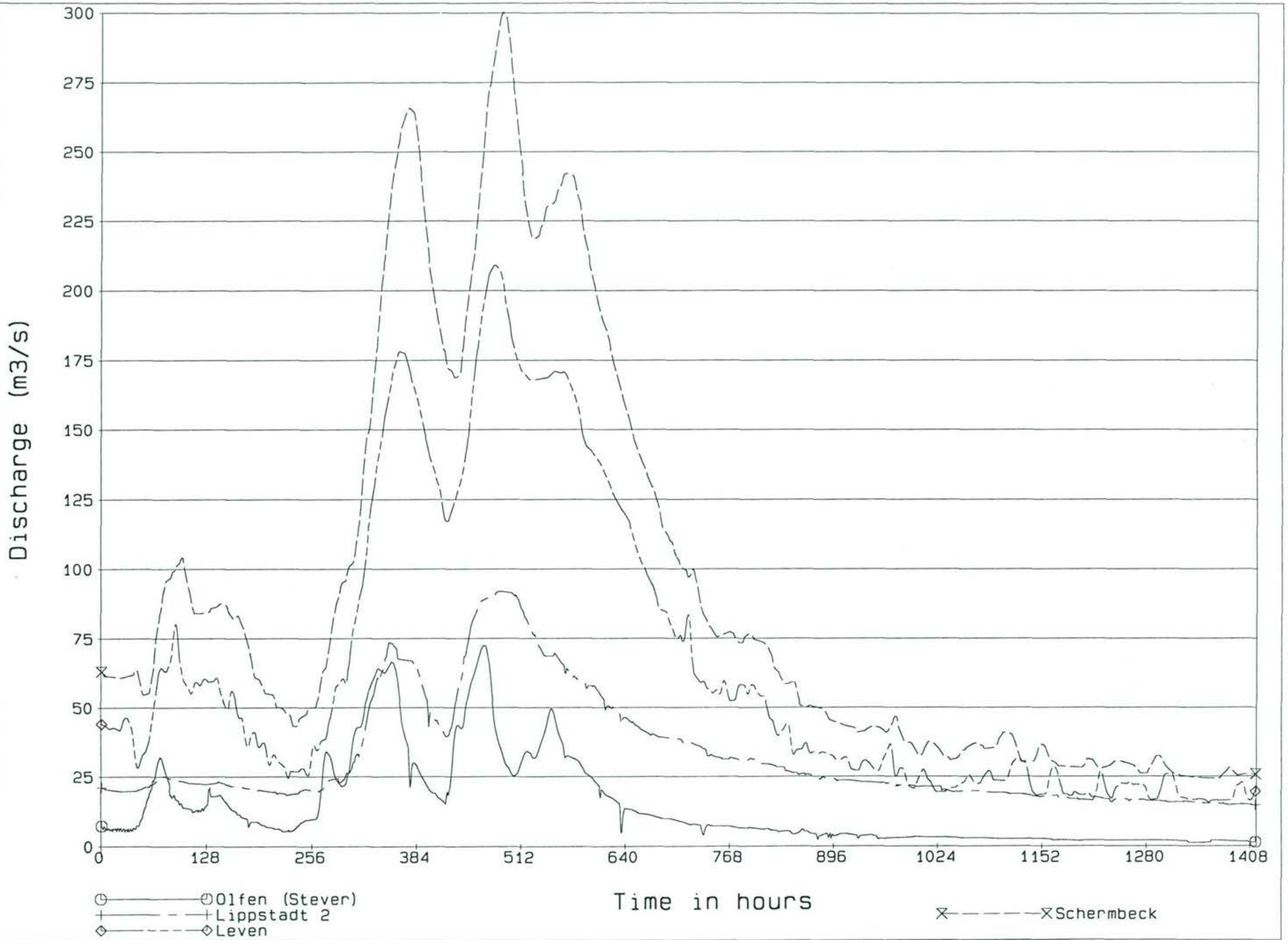
R3049

FIG. 4.2.6

DELFT HYDRAULICS

Hydrographs Lippe river and tributary

Period 7: 1/1/1986 - 28/2/1986

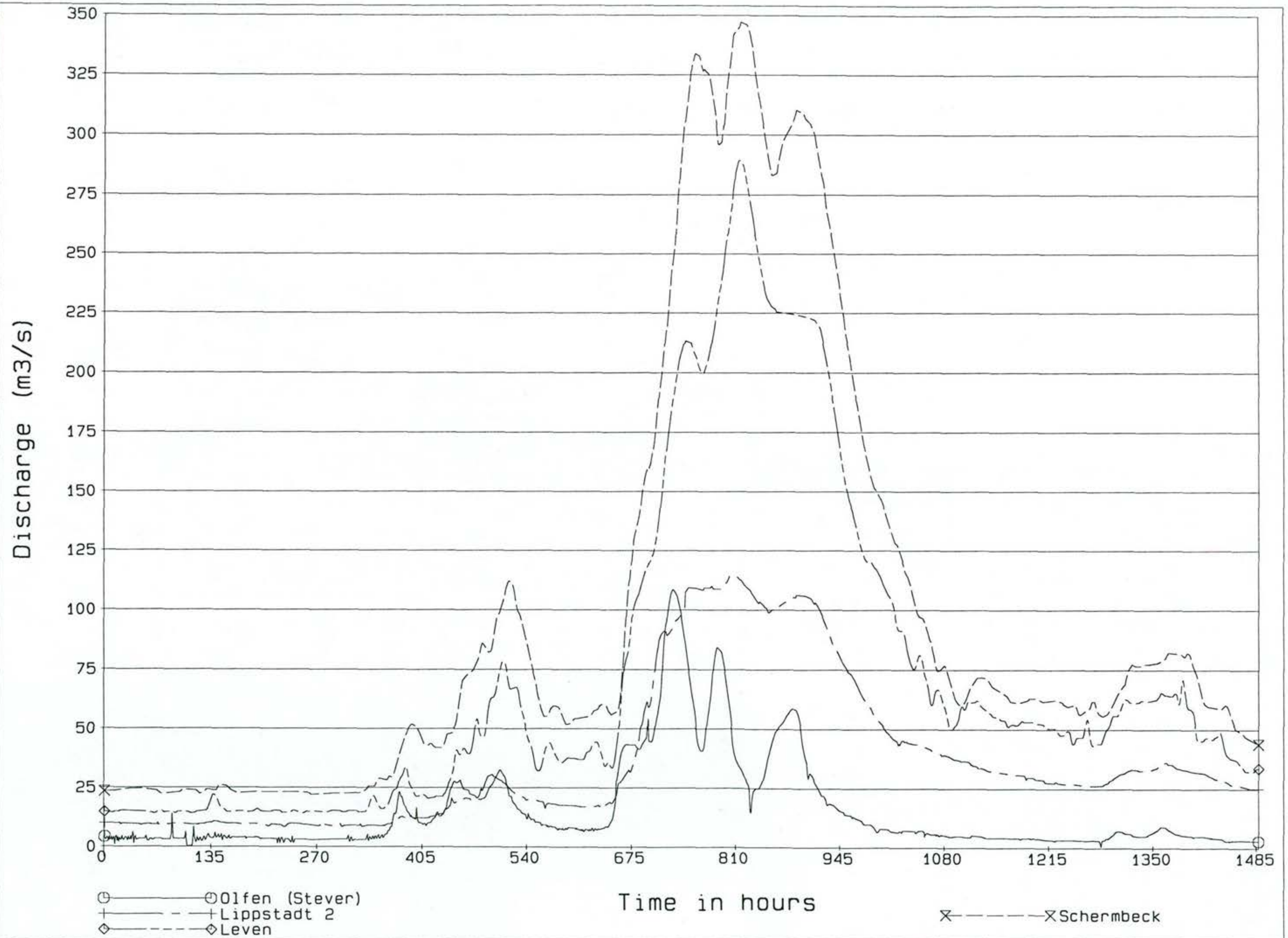


R3049

FIG.4.2.7

DELFT HYDRAULICS

Hydrographs Lippe river and tributary
Period 8: 1/12/1986 - 31/1/1987



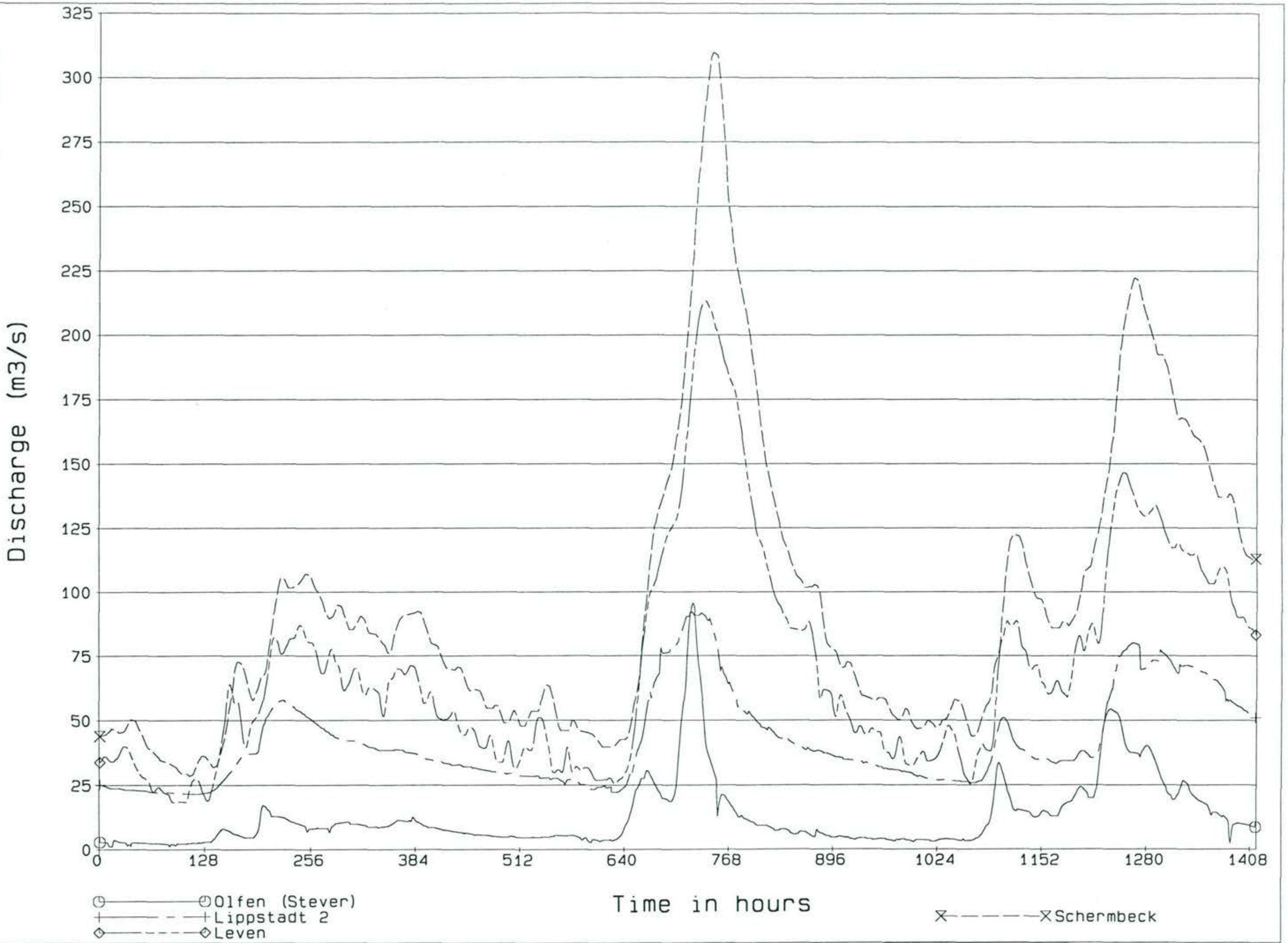
R3049

FIG. 4.2.8

Hydrographs Lippe river and tributary

Period 9: 1/2/1987 - 31/3/1987

DELFT HYDRAULICS

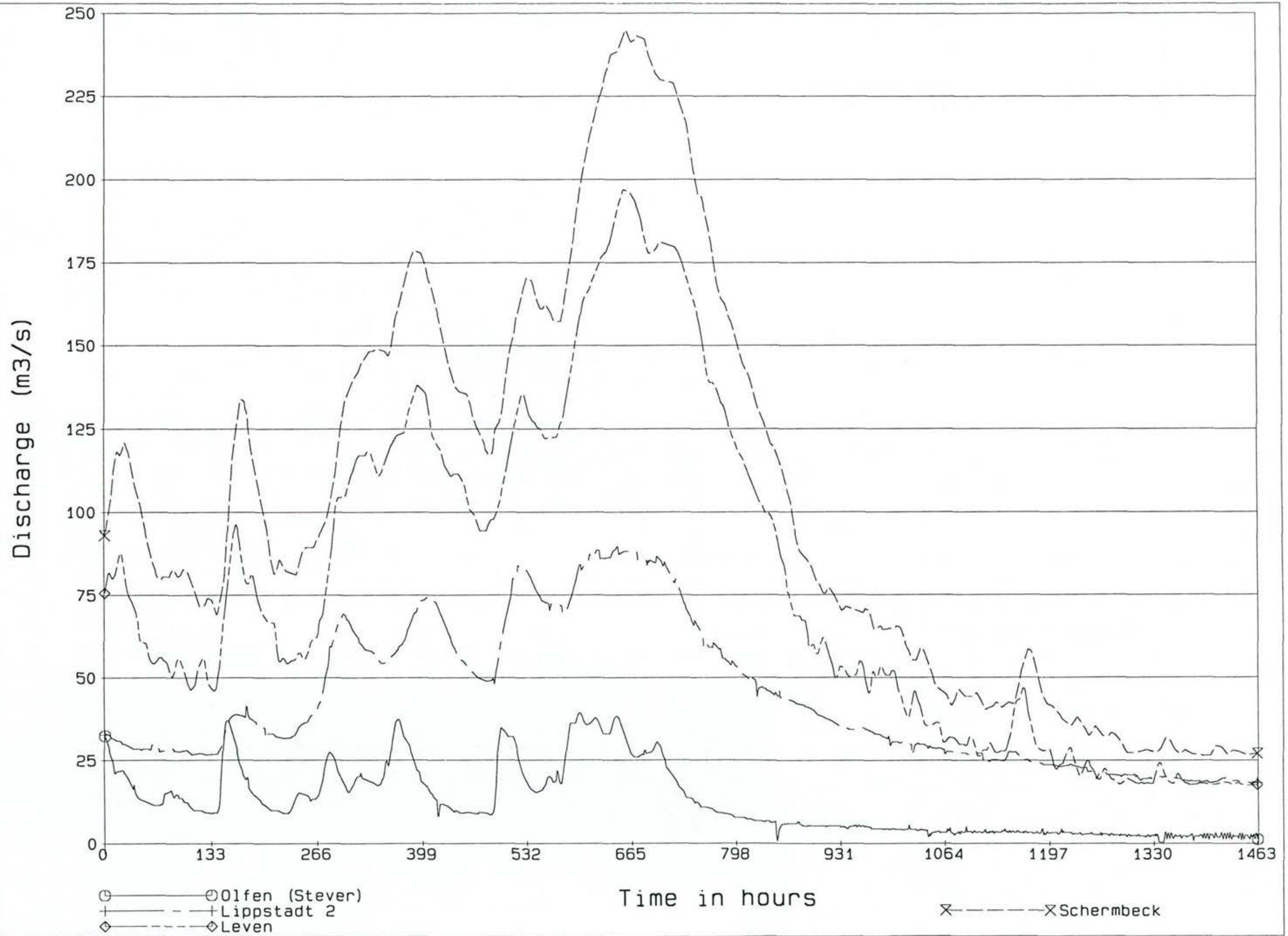


R3049

FIG. 4.2.9

DELFT HYDRAULICS

Hydrographs Lippe river and tributary
Period 10: 1/3/1988 - 30/4/1988



R3049

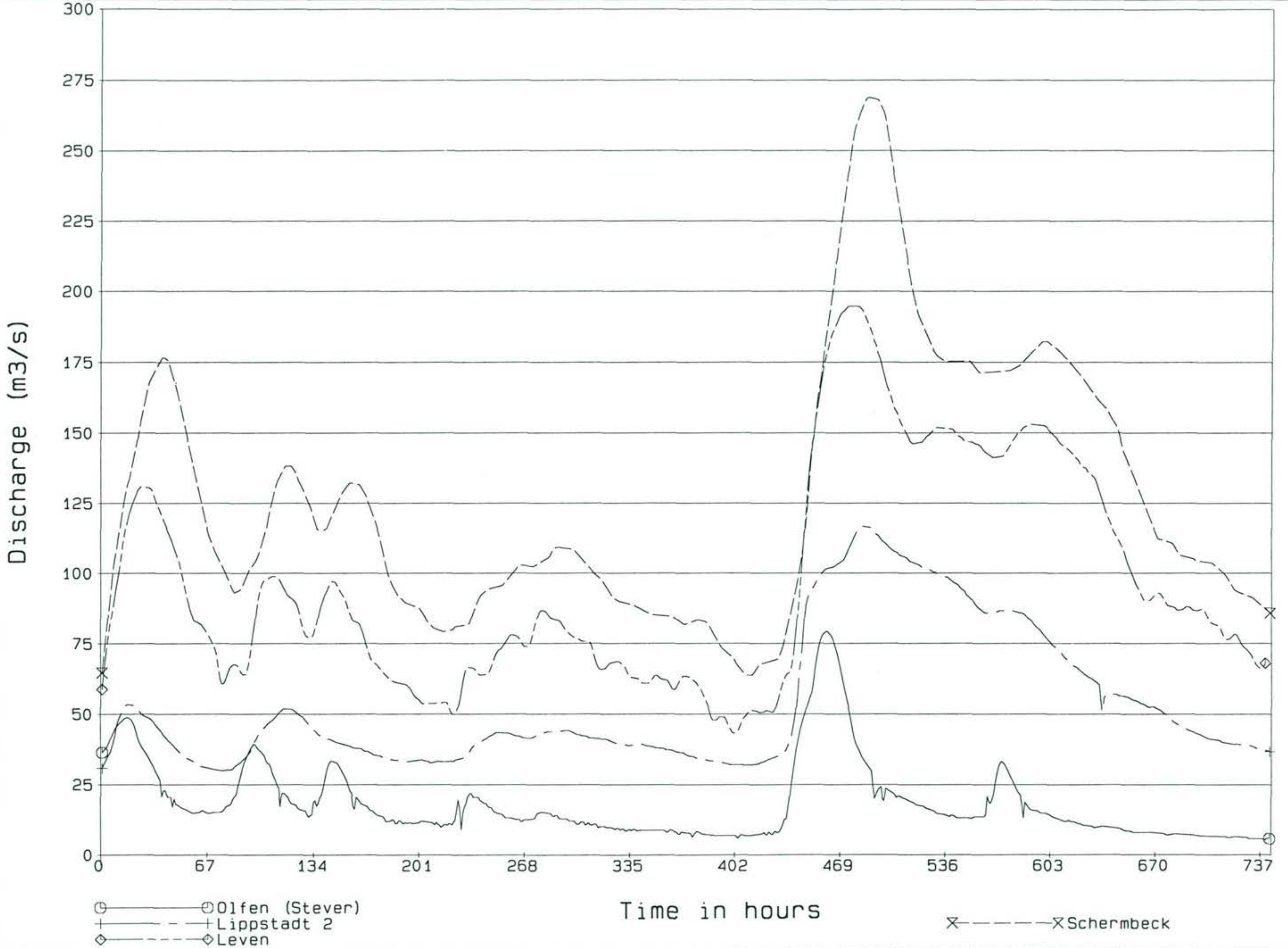
FIG. 4.2.10

Hydrographs Lippe river and tributary
Period 11: 1/12/1988 - 31/12/1988

DELFT HYDRAULICS

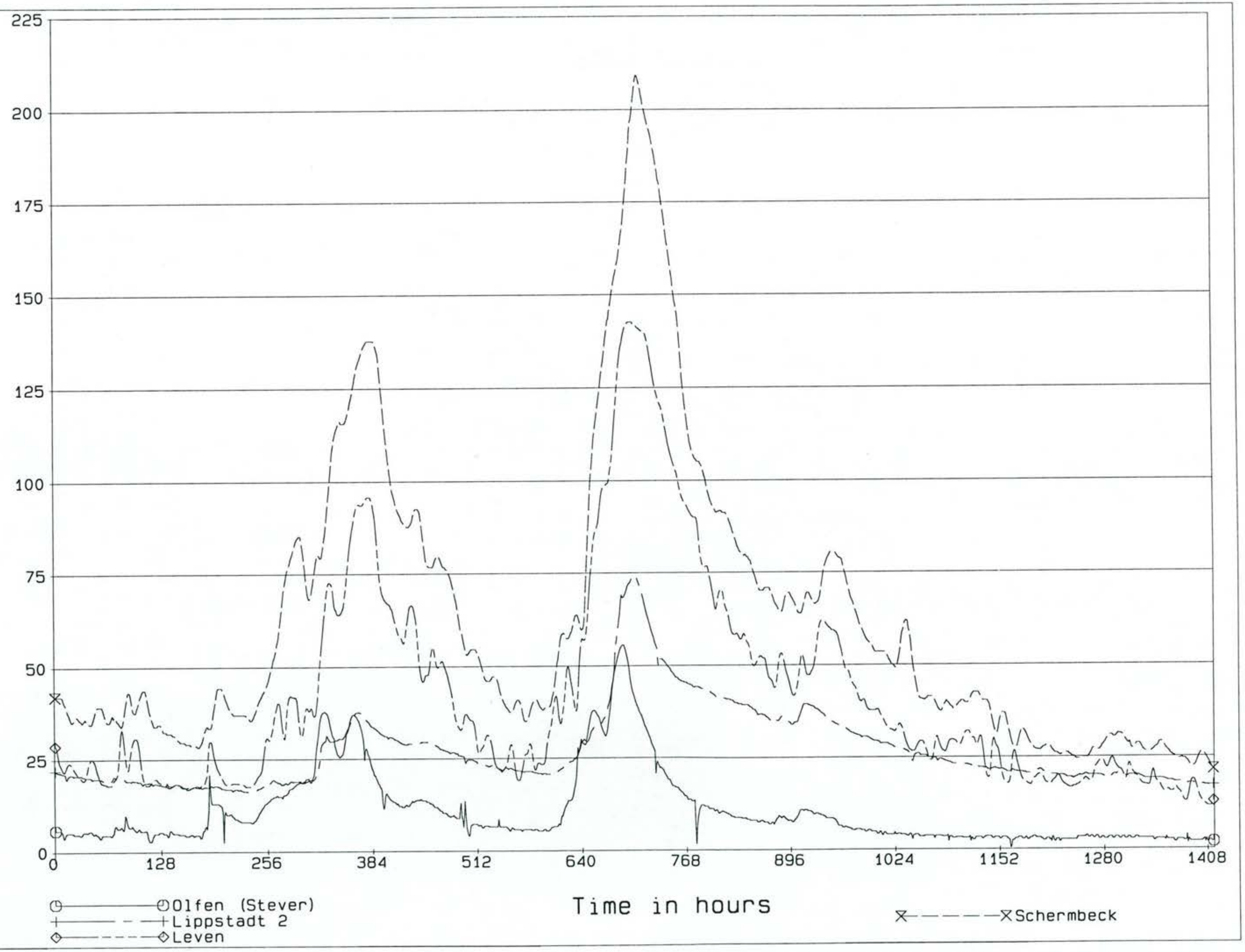
R3049

FIG. 4.2.11



Hydrographs Lippe river and tributary

Period 12: 1/2/1990 - 31/3/1990

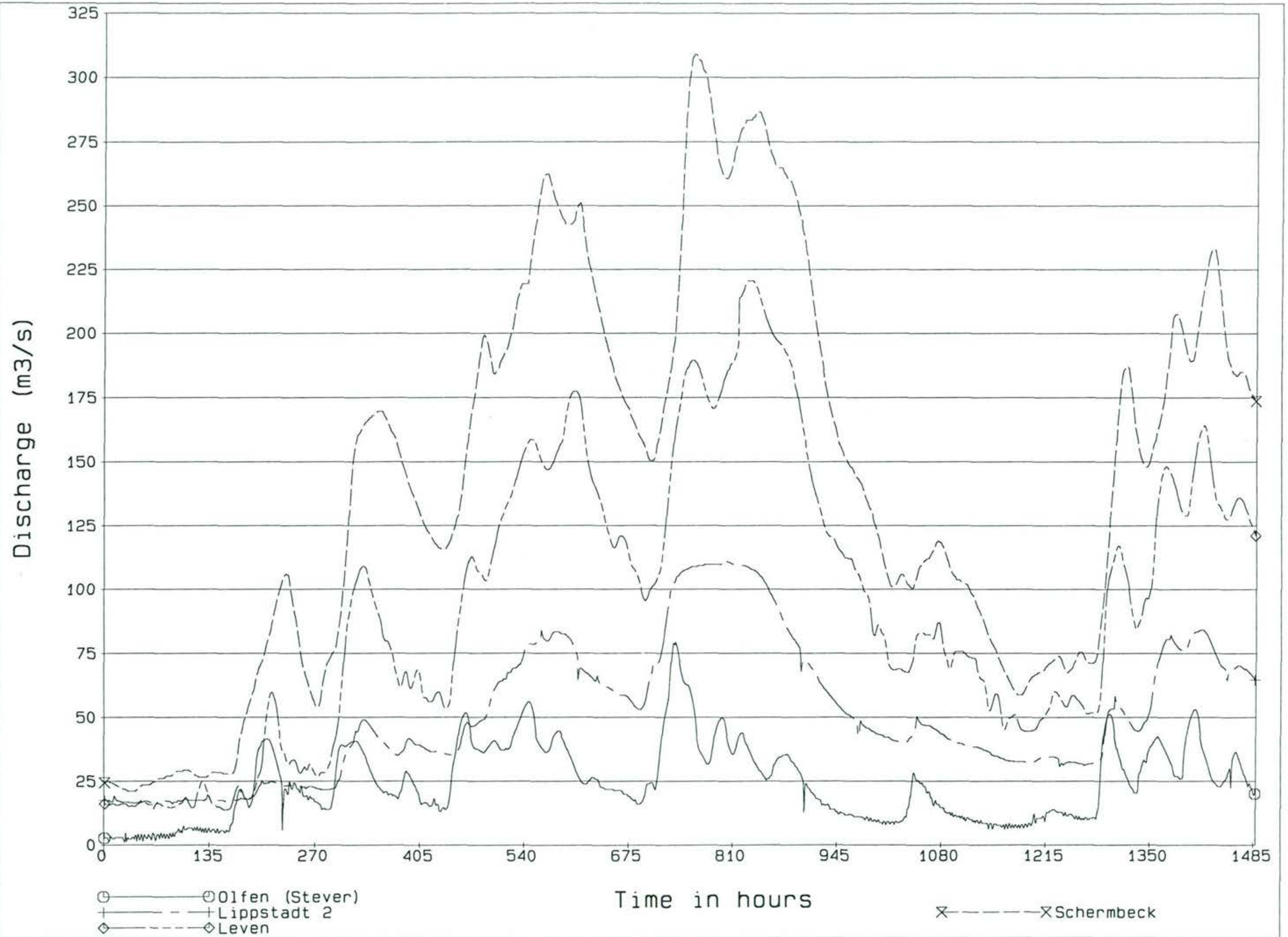


DELFT HYDRAULICS

R3049

FIG. 4.2.12

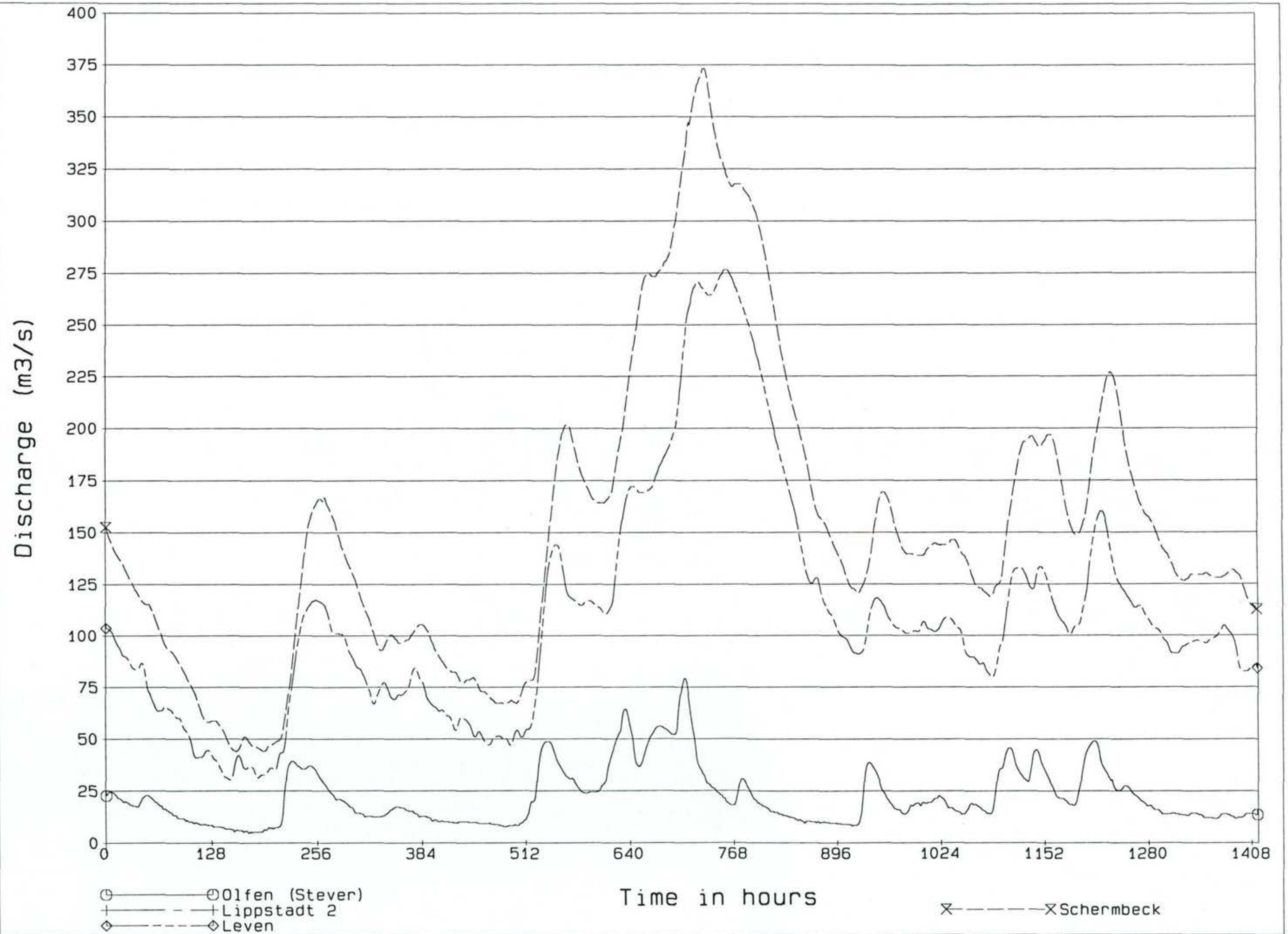
Hydrographs Lippe river and tributary
Period 13: 1/12/1993 - 31/1/1994



DELFT HYDRAULICS

R3049

FIG. 4.2.13



Hydrographs Lippe river and tributary

Period 14: 1/1/1995 - 28/2/1995

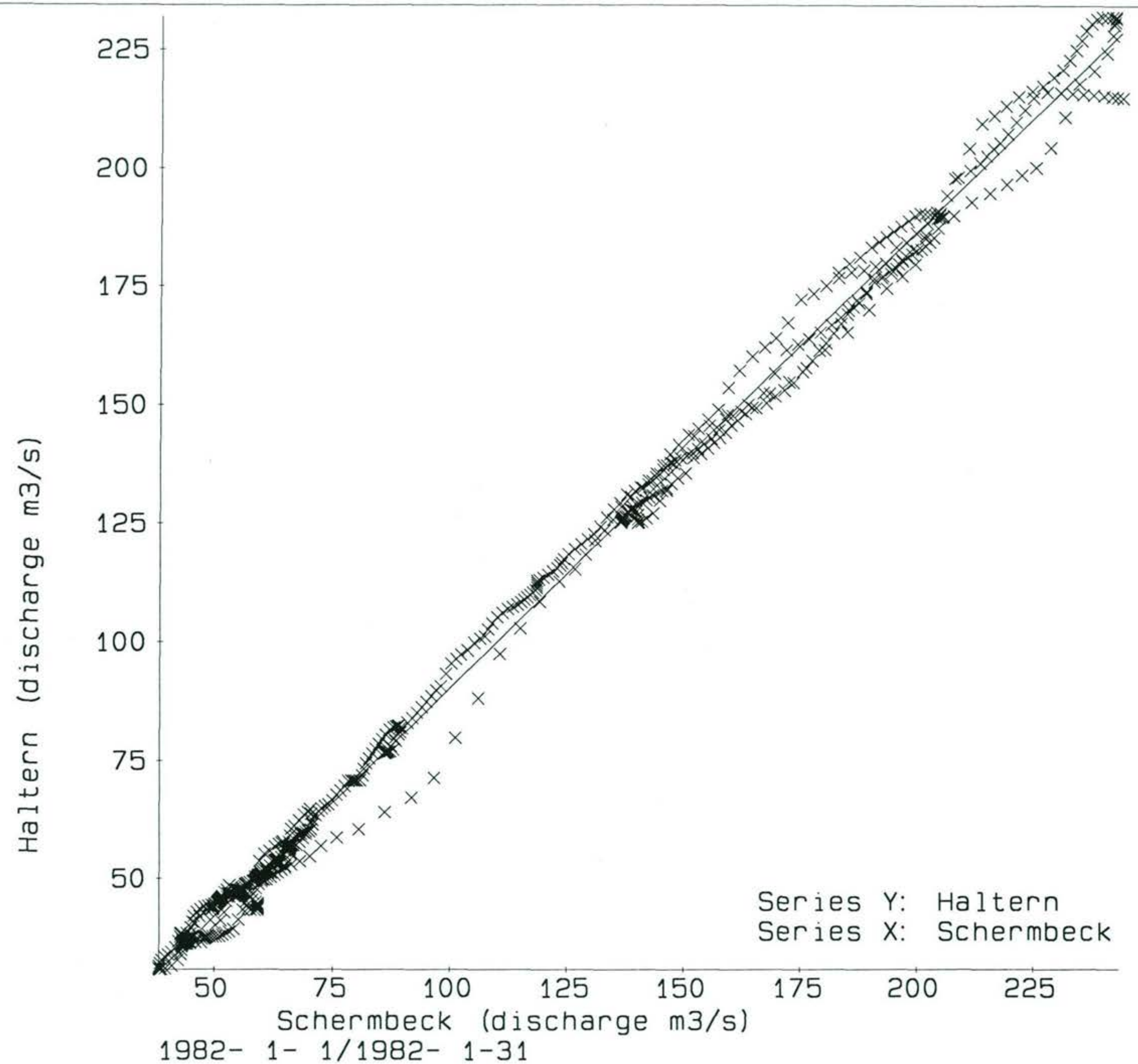
DELFT HYDRAULICS

R3049

FIG. 4.2.14

DELFT HYDRAULICS

Relation curve Haltern - Schermbeck
Period 2: 1/1/1982 - 31/1/1982

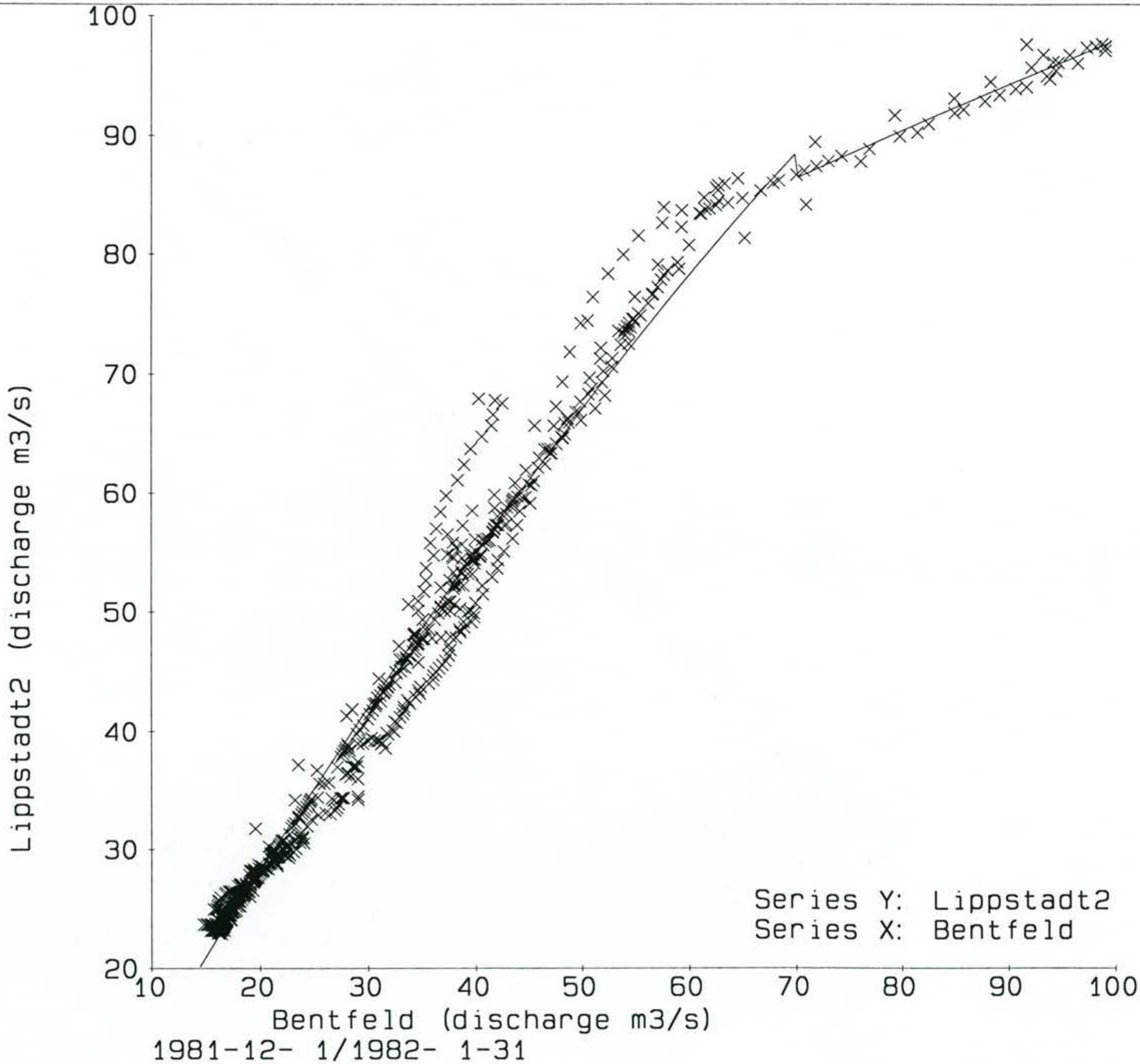


R3049

FIG. 4.3

DELFT HYDRAULICS

Relation curve Lippstadt2 - Bentfeld
Period 2: 1/12/1981 - 31/1/1982



R3049

FIG. 4.4

Figures of Chapter 5

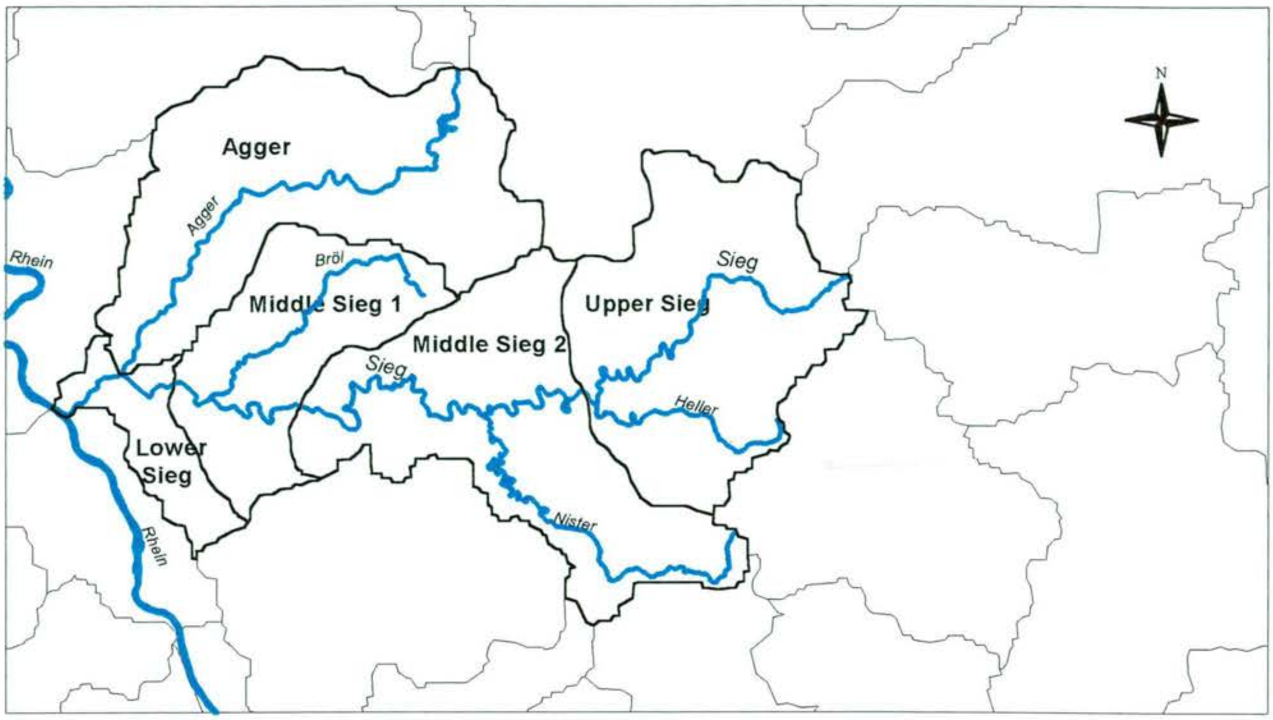


Fig 5.1 Sieg basin, division into subbasins

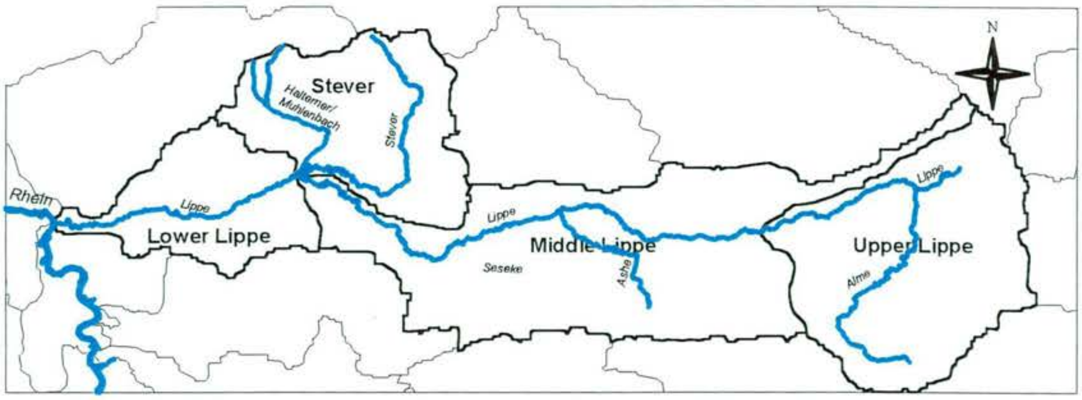


Fig 5.2 Lippe basin, division into subbasins

Legend:

Sieg: river Sieg

Lower Sieg: Lower Sieg basin

Figures of Chapter 6

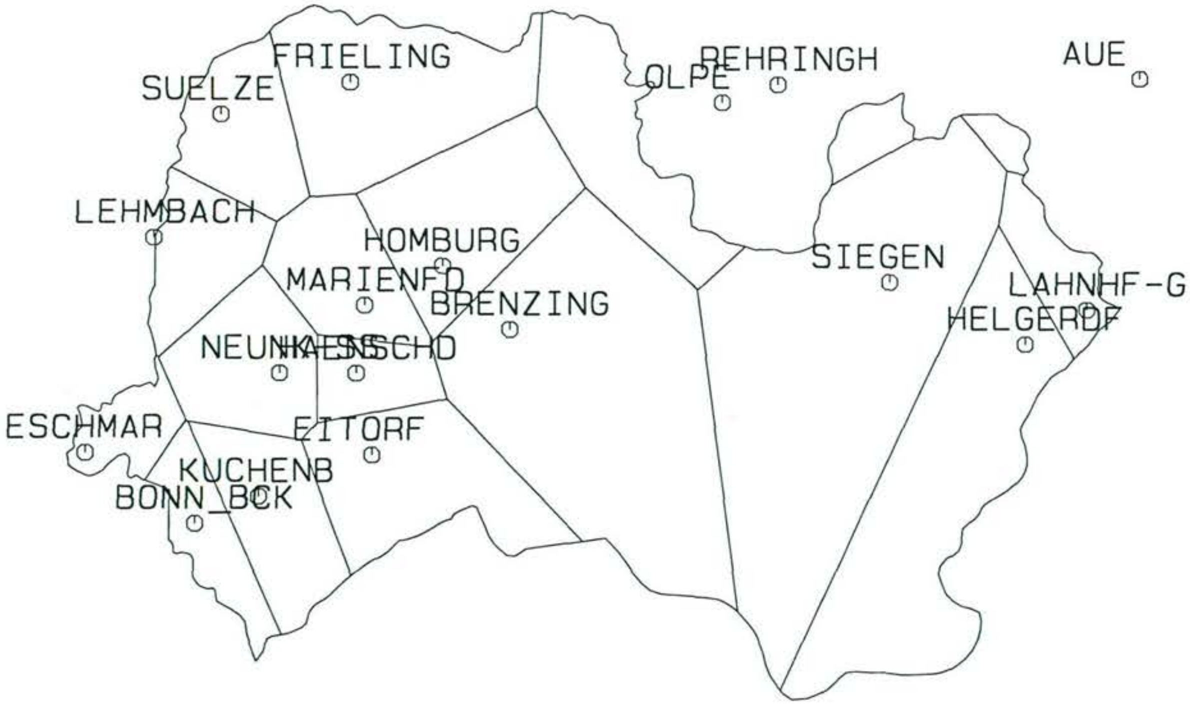


Fig. 6.1a Thiessen polygons for the areal rainfall in the total Sieg basin (Period 7 - 11)

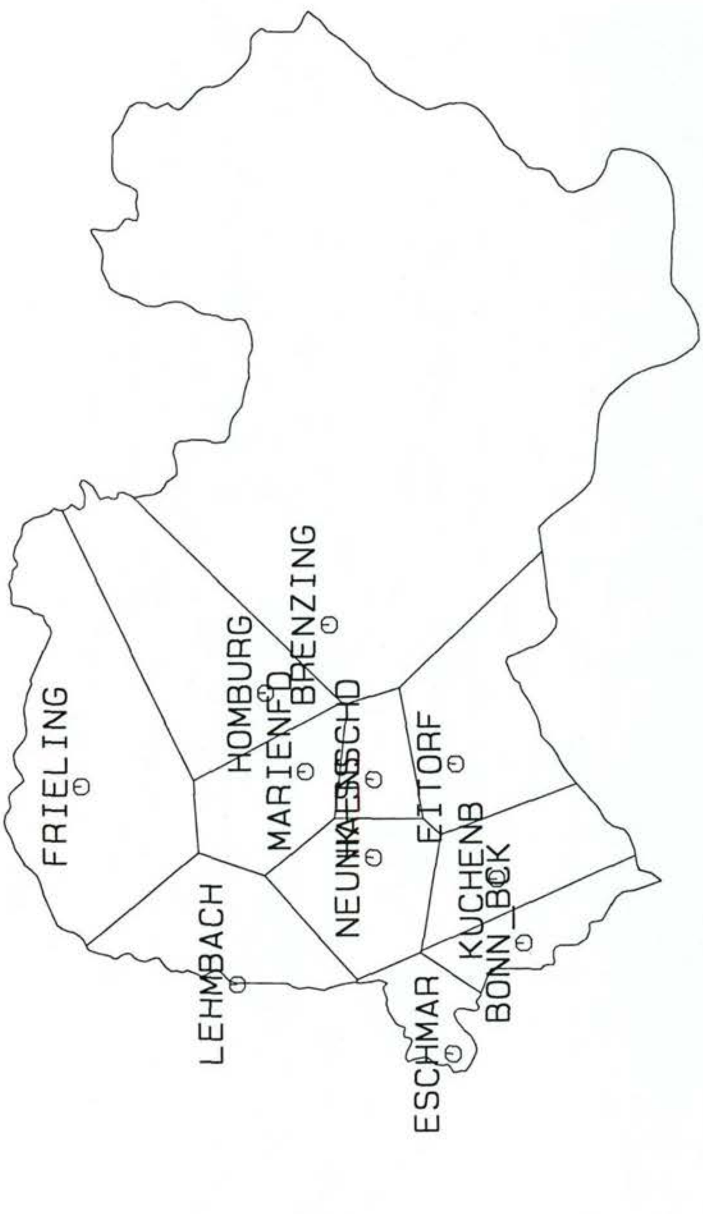
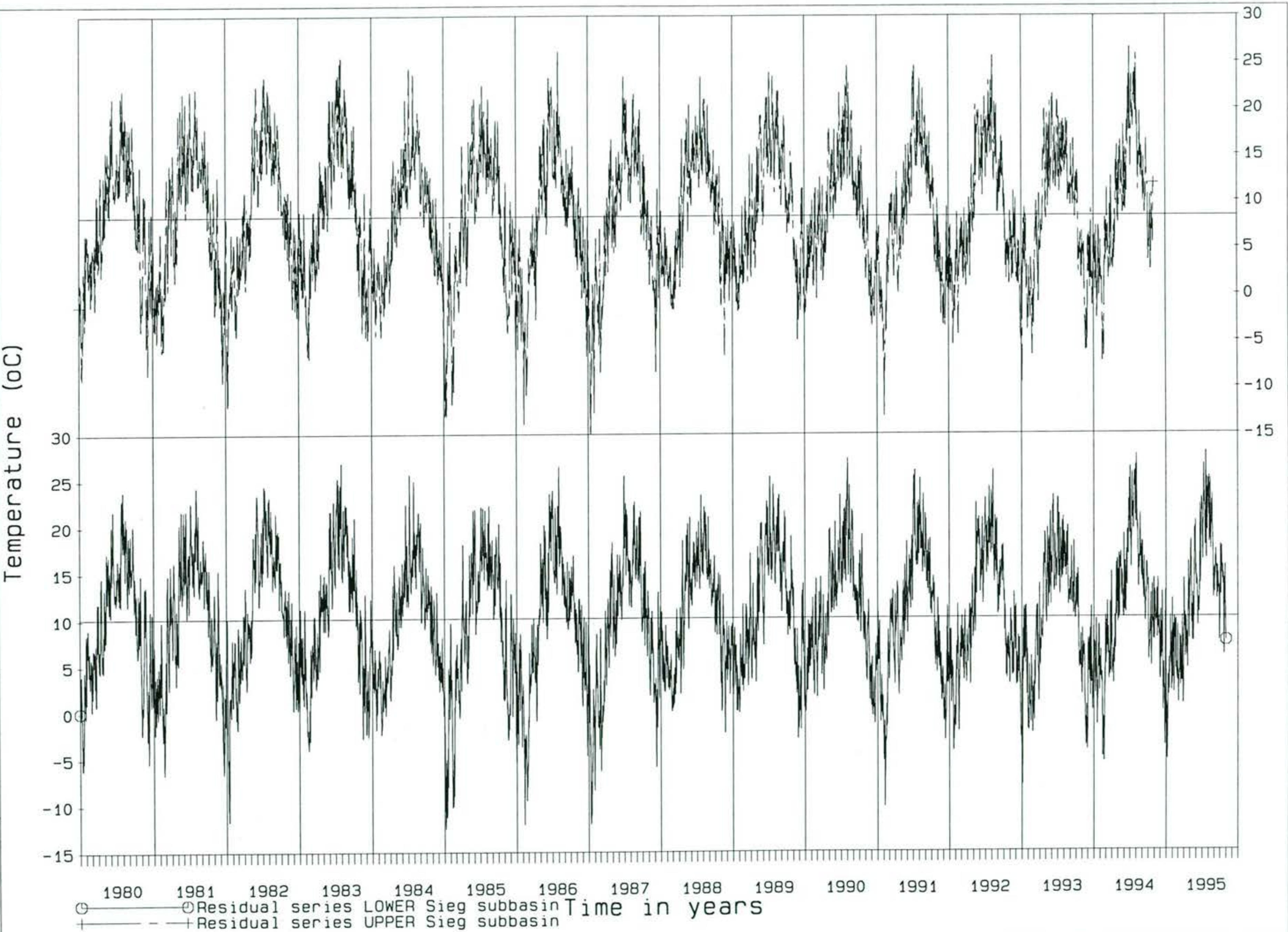


Fig. 6.1b Thiessen polygons for the areal rainfall in the total Sieg basin (Period 13)

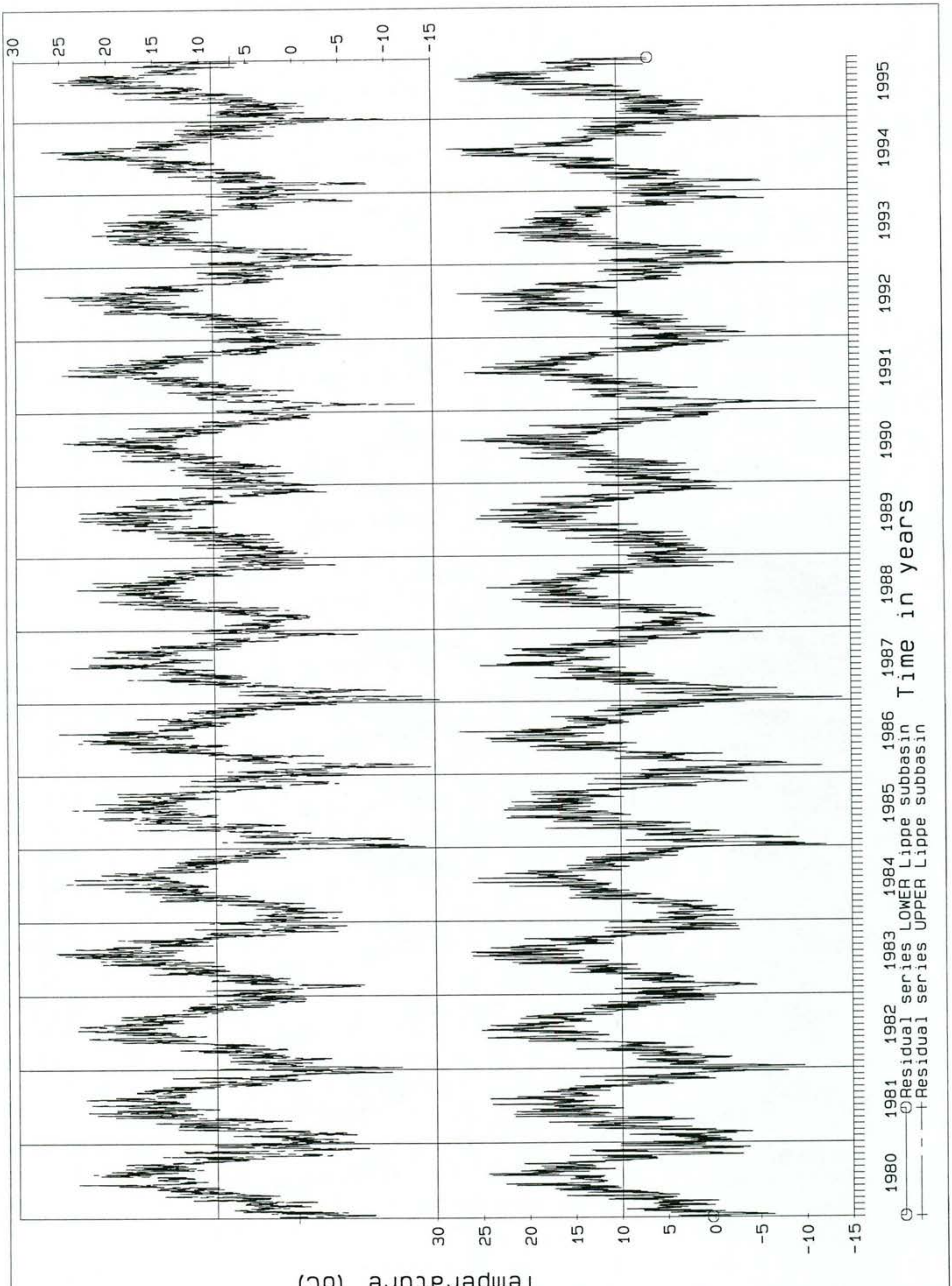
DELFT HYDRAULICS

Residual series average daily temp.
Lower and Upper Sieg subbasins
Period 1980 - 1995



R3049

FIG. 6.2



Residual series average daily temp.
Lower and Upper Lippe basins
Period 1980 - 1995

DELFT HYDRAULICS | R3049 | FIG. 6.3

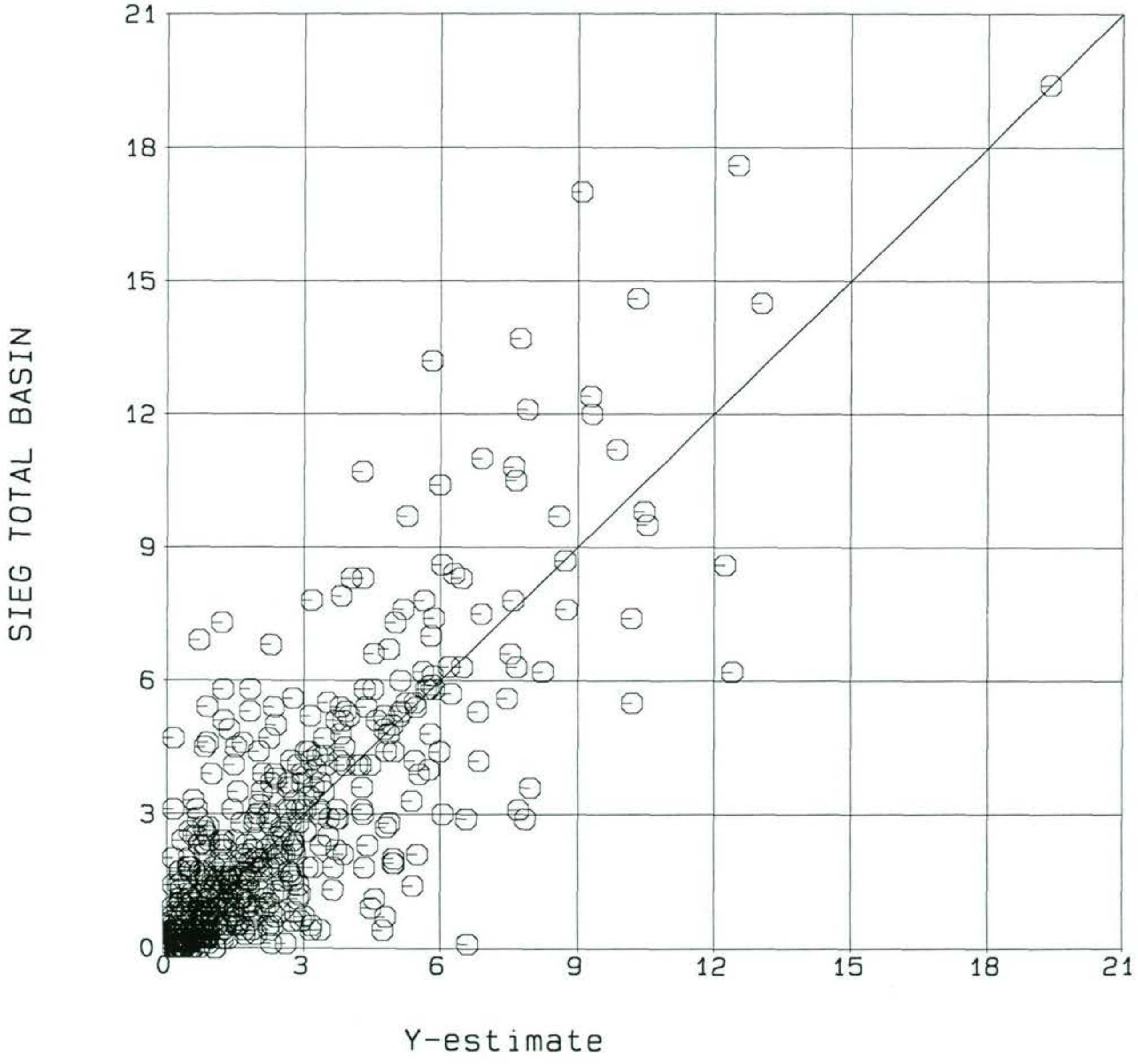
Figures of Chapter 7

Multiple regression

Regression coefficients :

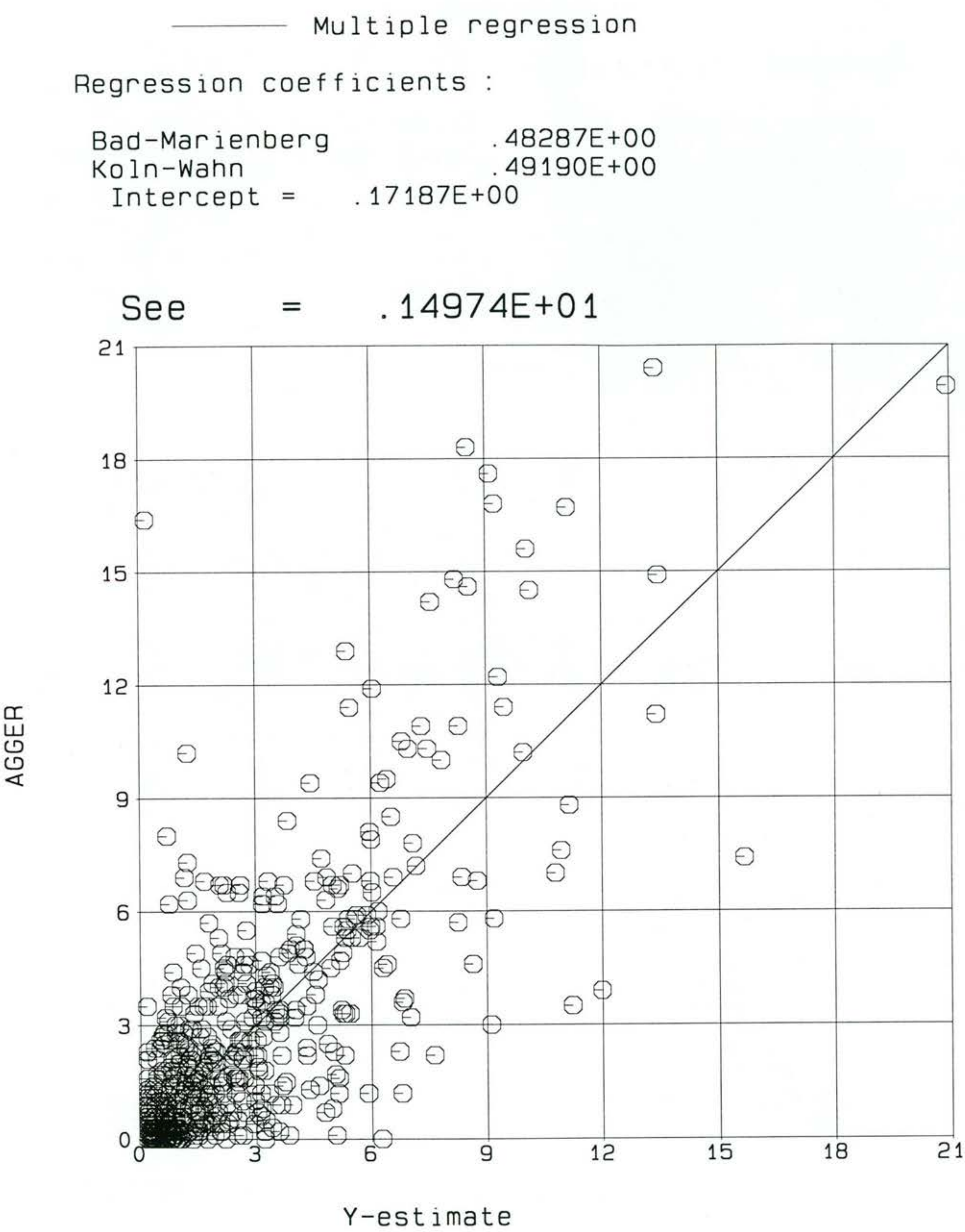
Bad-Marienberg .51260E+00
Koln-Wahn .35007E+00
Intercept = .13379E+00

See = .11072E+01



Multiple regression climatic stations and Sieg total basin areal rainfall

DELFT HYDRAULICS | R3049 | FIG. 7.1.1



Multiple regression climatic stations and Agger basin areal rainfall

DELFT HYDRAULICS | R3049 | FIG. 7.1.2

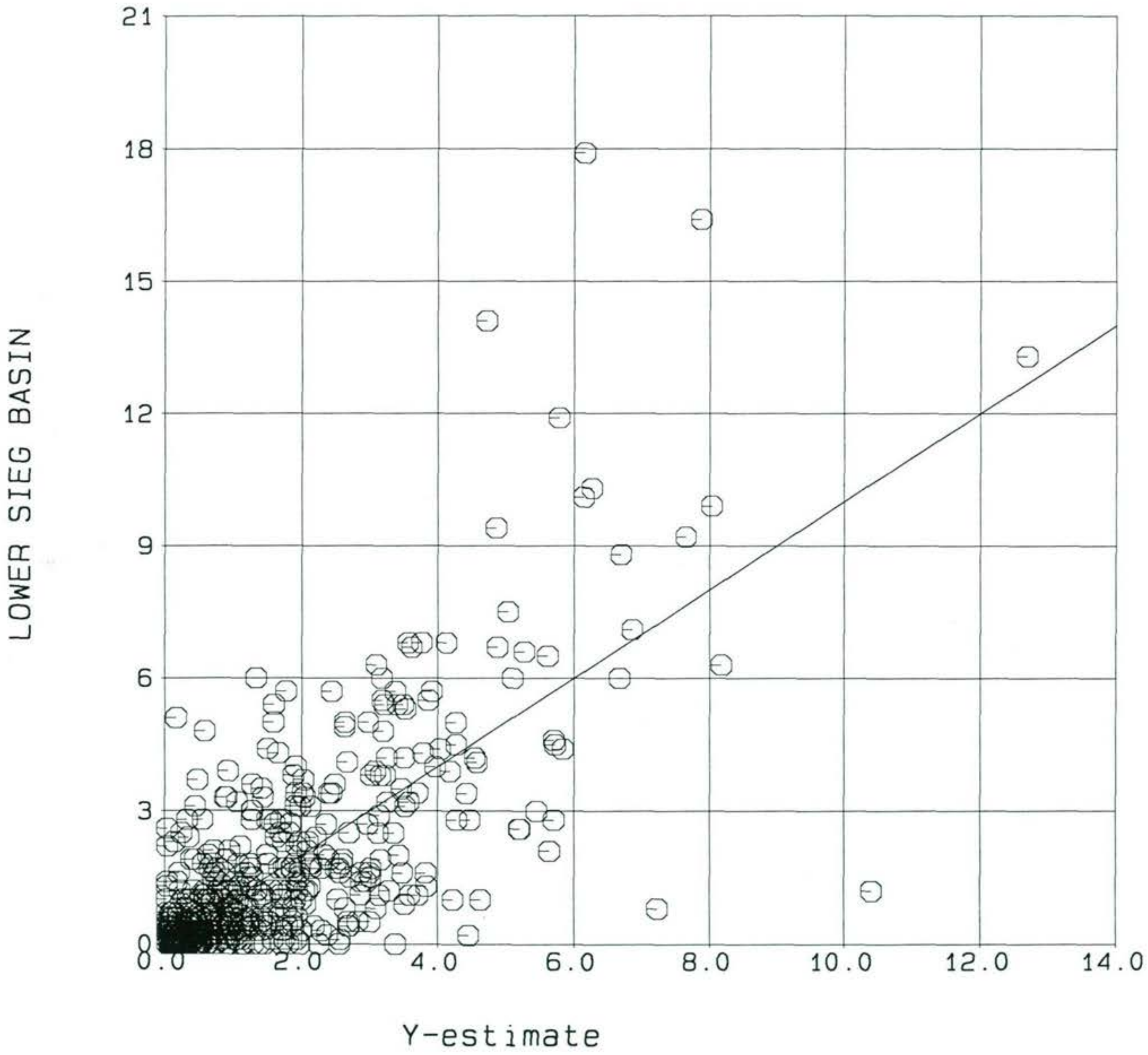
Multiple regression

Regression coefficients :

Bad-Marienberg	.26491E+00
Koln-Wahn	.34761E+00

Intercept = .34871E-01

See = .10202E+01



Multiple regression climatic stations
and Lower Sieg basin areal rainfall

DELFT HYDRAULICS

R3049

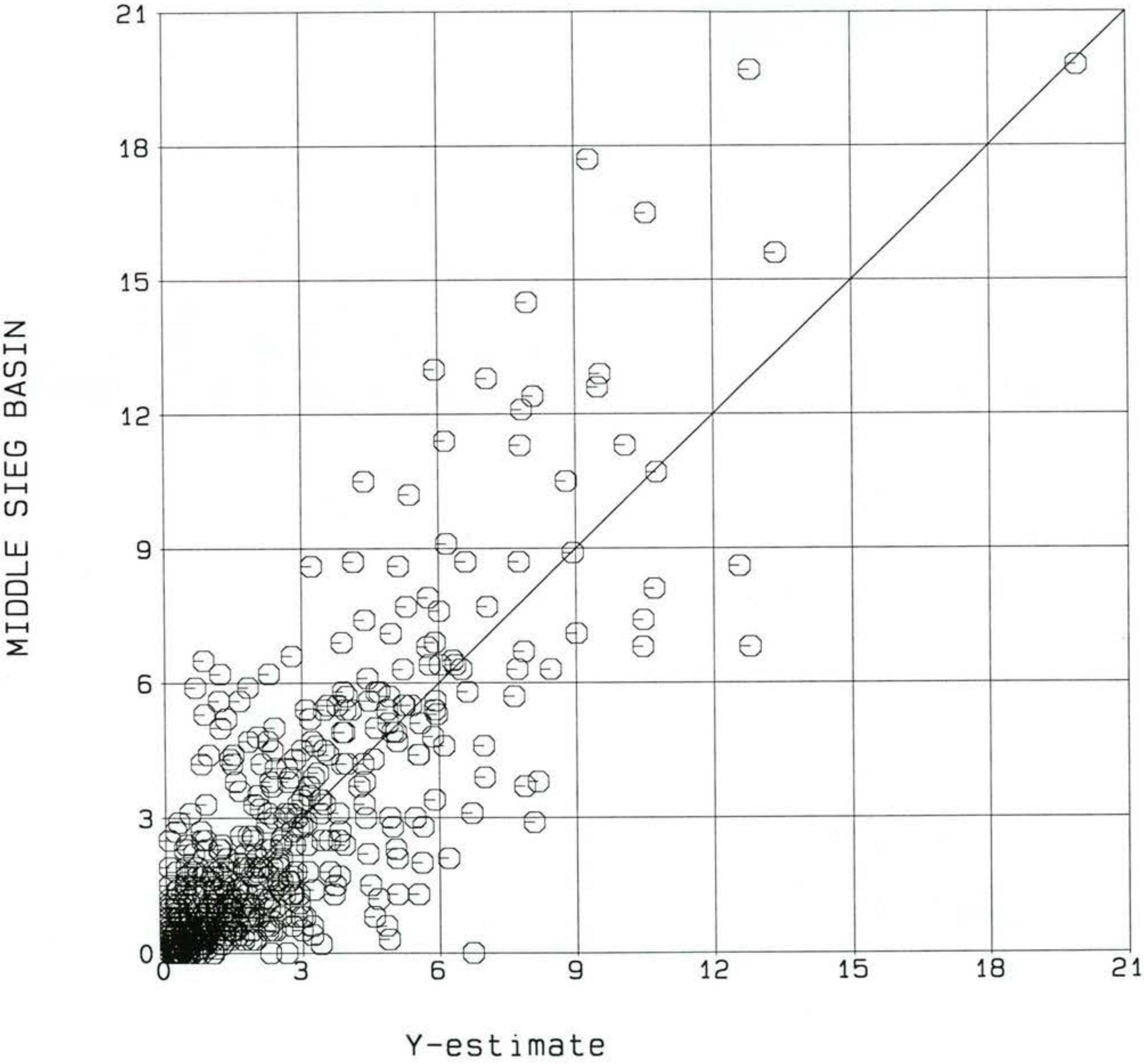
FIG. 7.1.3

Multiple regression

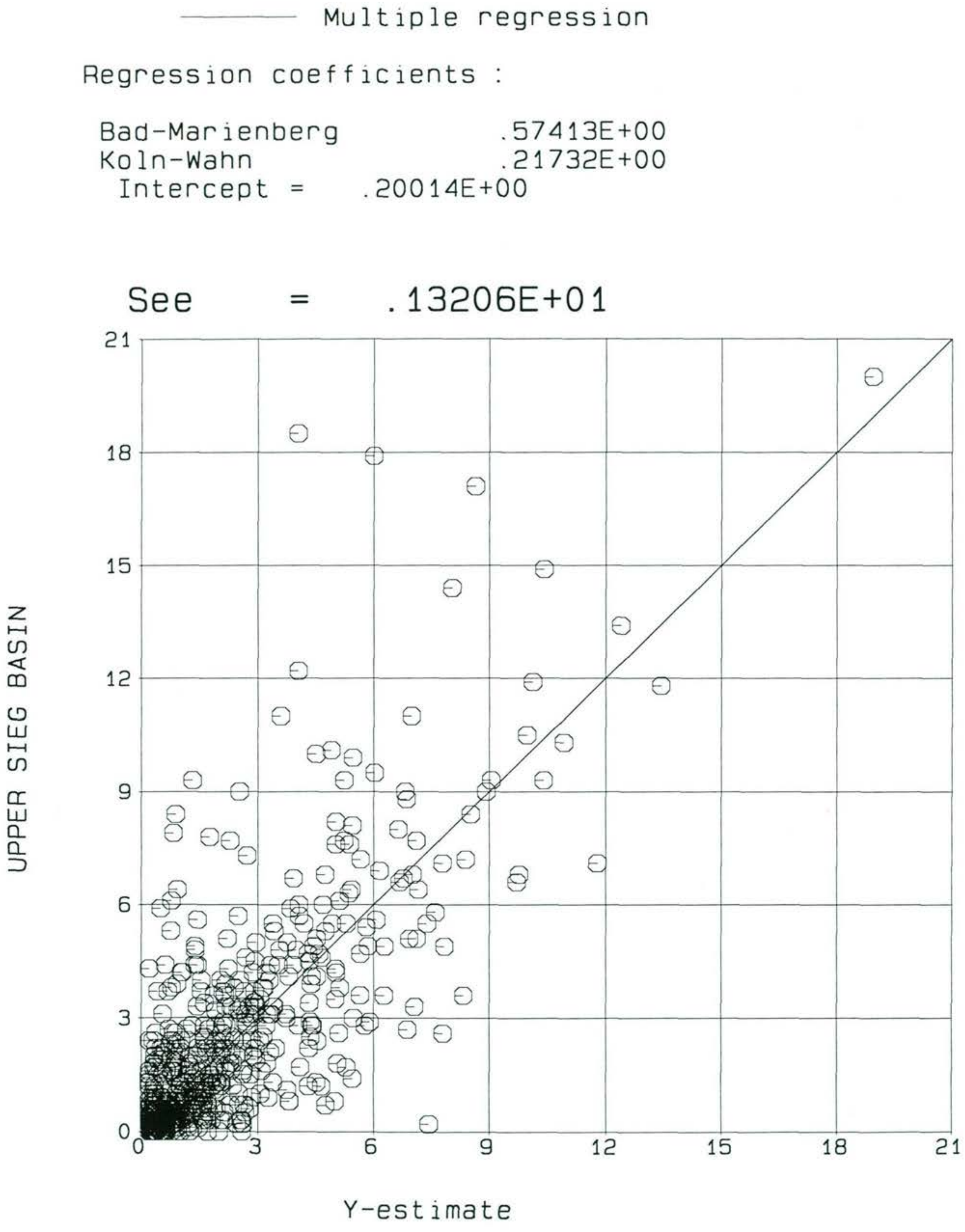
Regression coefficients :

Bad-Marienberg	.52631E+00
Koln-Wahn	.36434E+00
Intercept =	.83867E-01

See = .11614E+01



Multiple regression climatic stations and Middle Sieg basin areal rainfall		
DELFT HYDRAULICS	R3049	FIG. 7.1.4



Multiple regression climatic stations and Upper Sieg basin areal rainfall

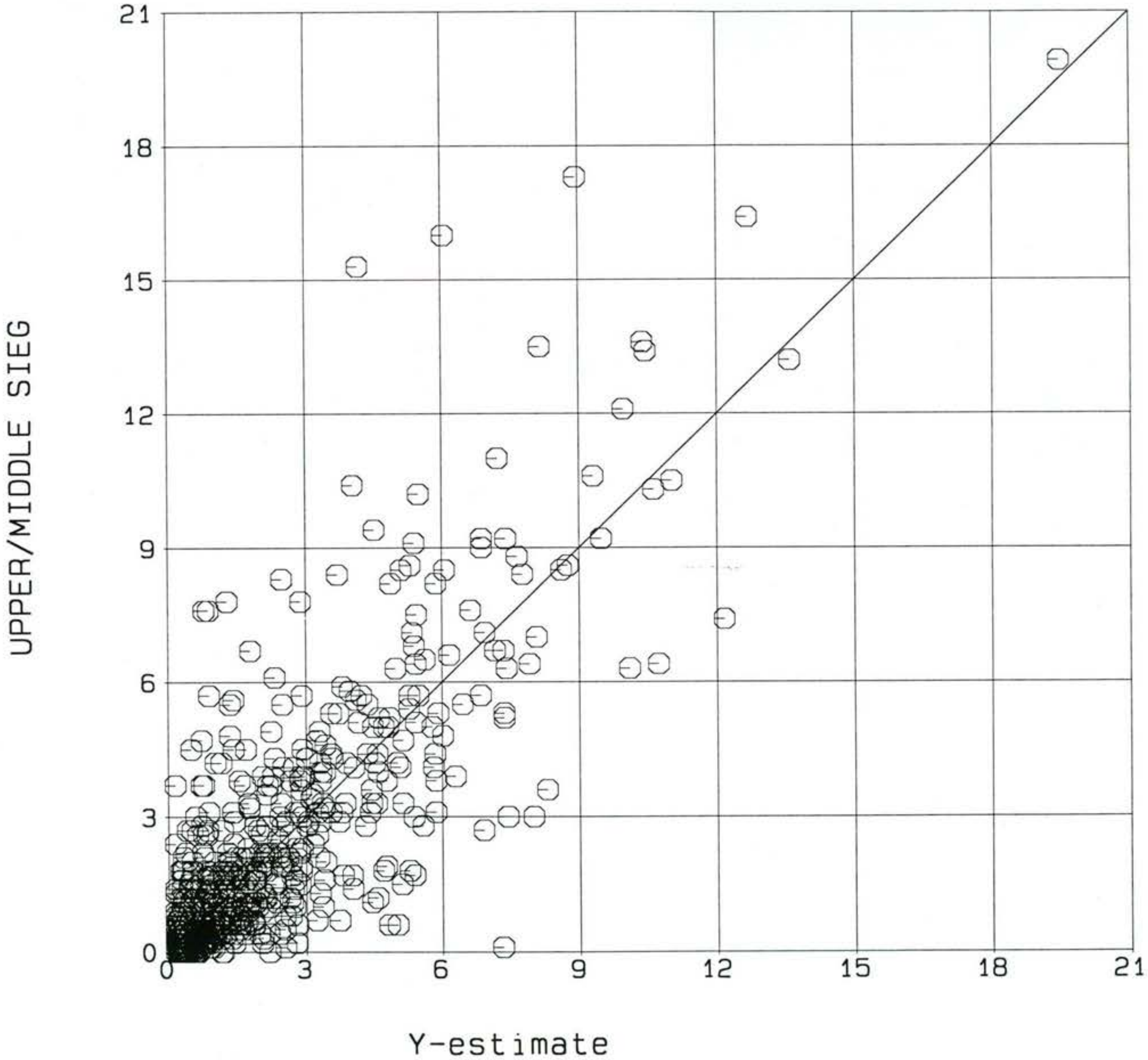
DELFT HYDRAULICS | R3049 | FIG. 7.1.5

—— Multiple regression

Regression coefficients :

Bad-Marienberg	.56900E+00
Koln-Wahn	.26280E+00
Intercept =	.14829E+00

See = .11840E+01



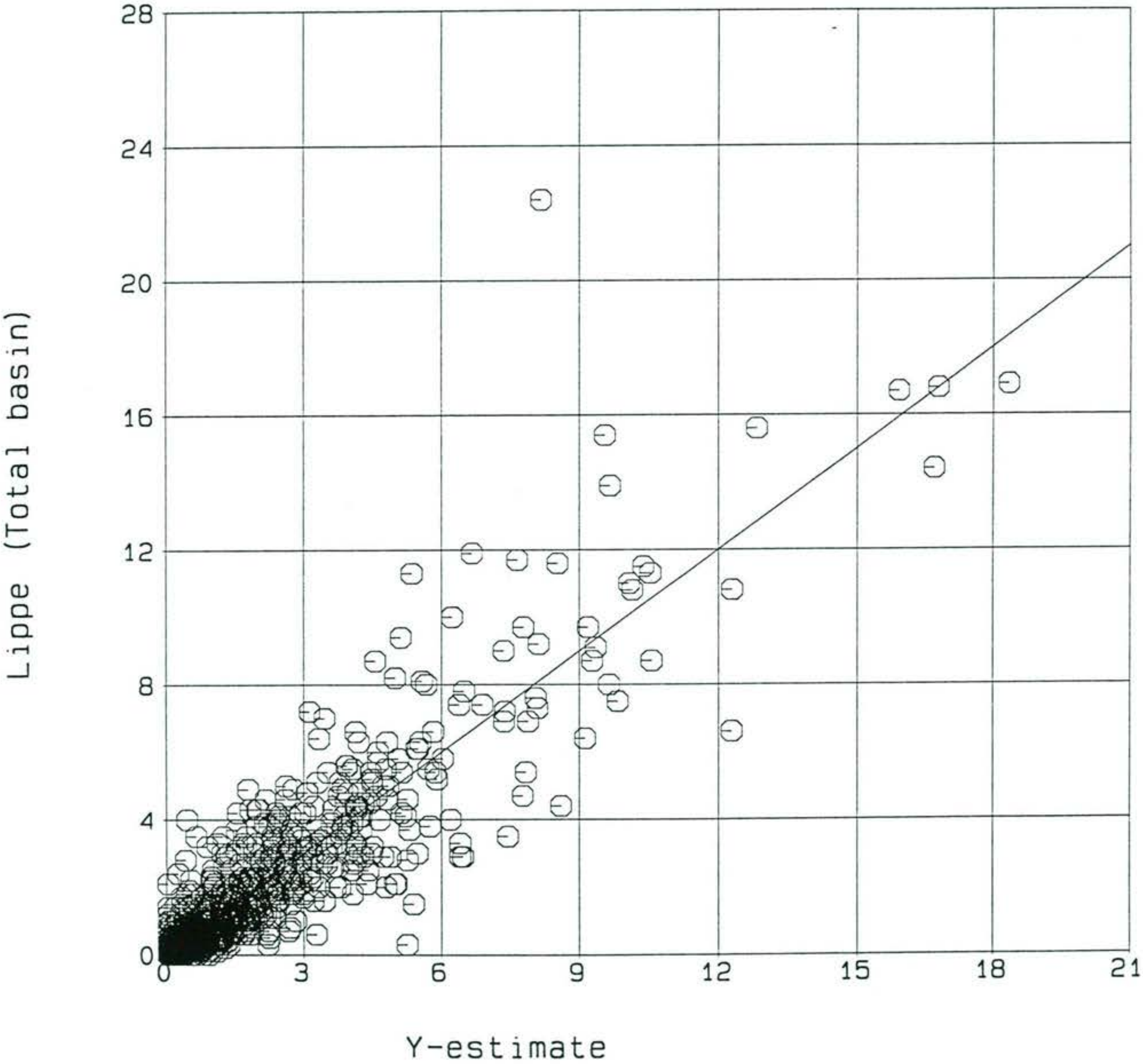
Multiple regression climatic stations and Middle/Upper Sieg areal rainfall		
DELFT HYDRAULICS	R3049	FIG. 7.1.6

Stepwise Regression

Regression coefficients :

Bad-Lippspring	.98834 E-01	Guetersloh	.19528 E+00
Bad-Salzuflen	.60974 E-01	Kahler-Ast	.83619 E-01
Bochalt-L	.96106 E-01	Munster	.22062 E+00
Dusseldorf	.65602 E-01		
Essen	.53779 E-01	Intercept	.34237 E-01

See = .77368E+00



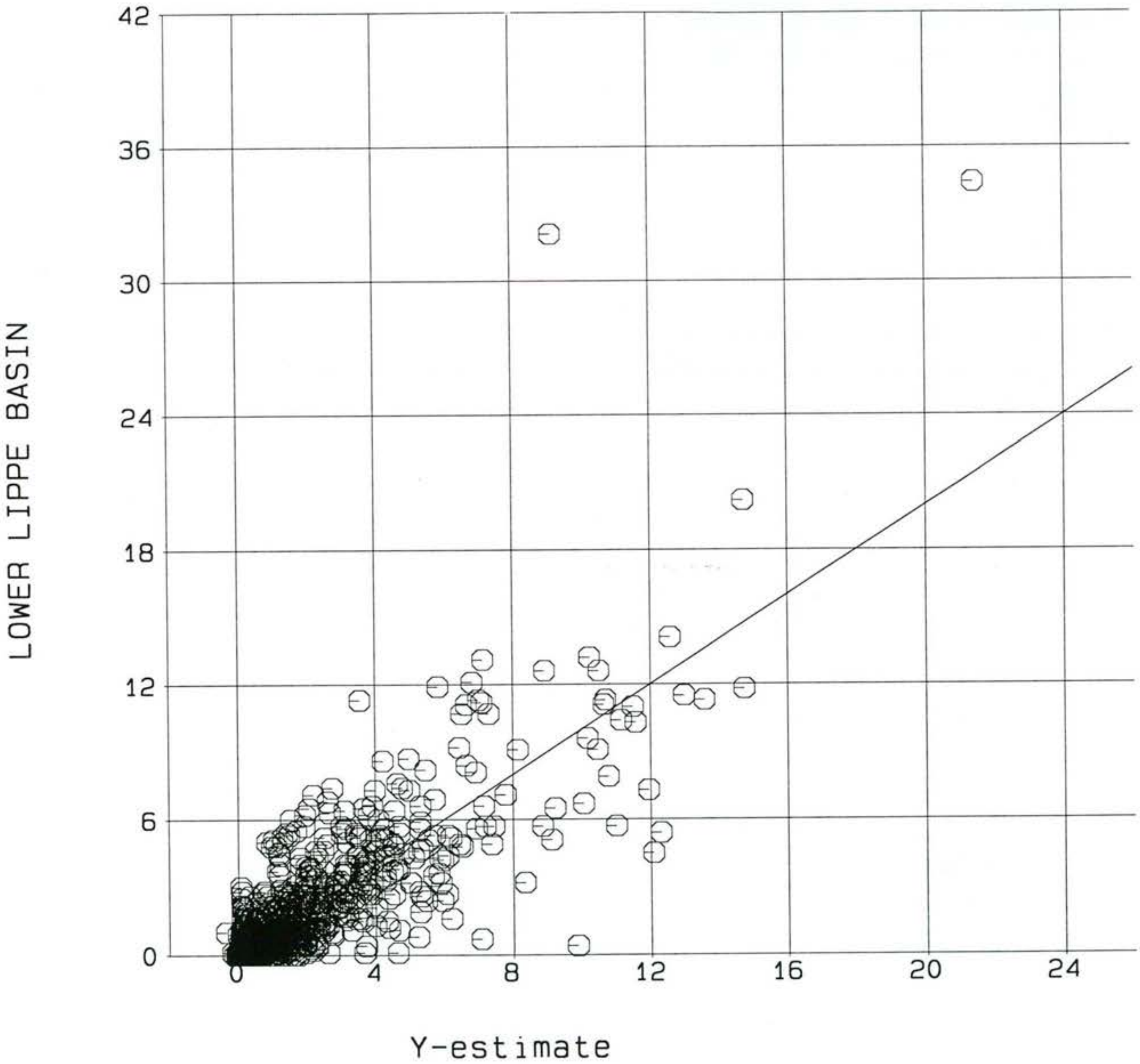
Multiple (step-wise) regression
Climatic stations and total Lippe
areal rainfall

DELFT HYDRAULICS | R3049 | FIG. 7.2.1

Stepwise Regression

Regression coefficients :

Bad-Salzuflen	.70686 E-01	Munster	.32905 E+00
Bocholt-L	.20786 E+00		
Dusseldorf	.12664 E+00	Intercept	.92065 E+01
Essen	.26698 E-00		
Luedenschd	-.57245 E-01		



Multiple (step-wise) regression
Climatic stations and Lower Lippe
areal rainfall

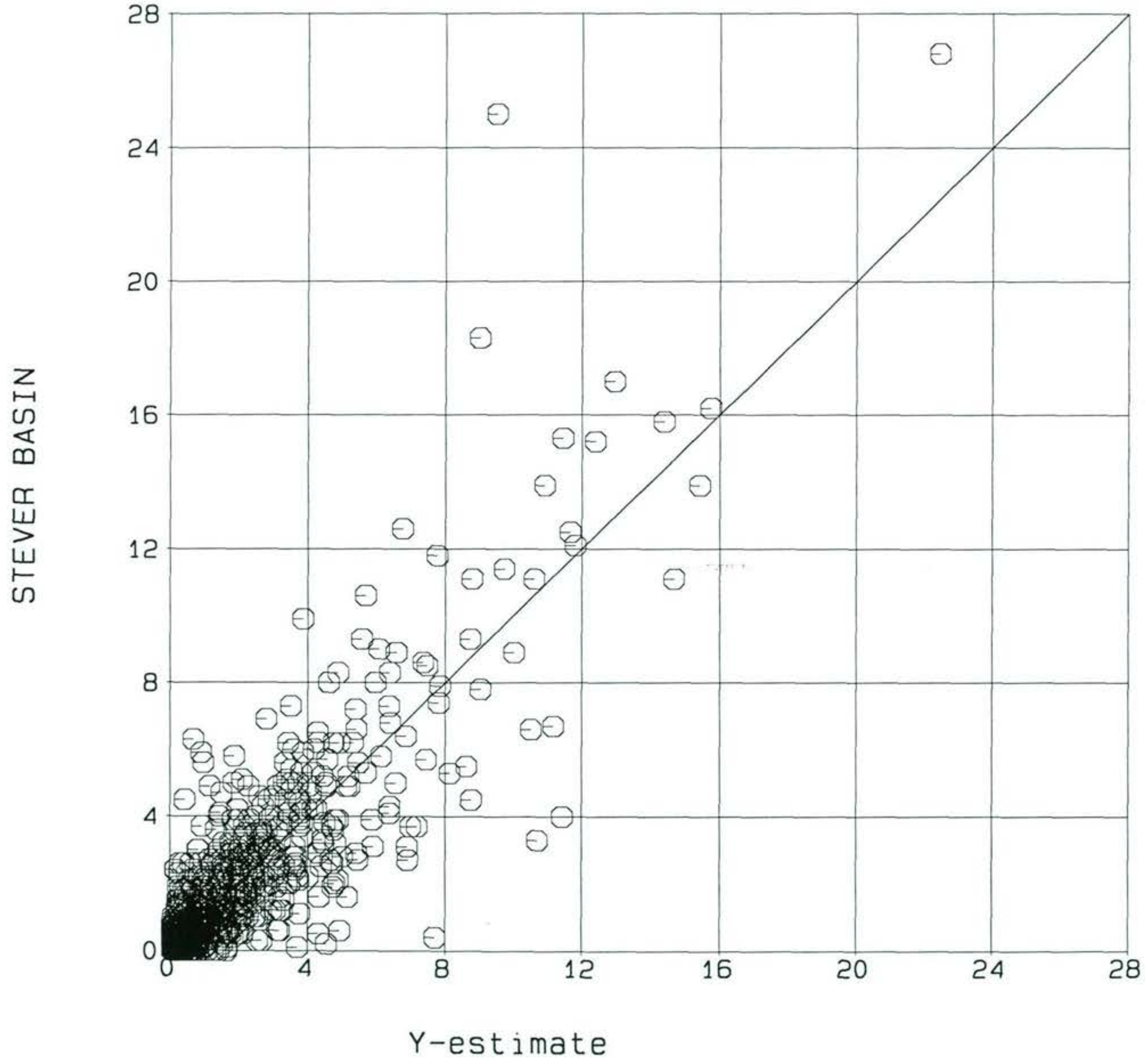
DELFT HYDRAULICS | R3049 | FIG. 7.2.2

Stepwise Regression

Regression coefficients :

Bocholt-L	.19070 E+00	Intercept	.52002 E-01
Dusseldorf	.66233 E-01		
Guetersloh	.90475 E-01		
Kahler-Ast	.31855 E-01		
Munster	.53647 E+00		

See = .93539E+00



Multiple (step-wise) regression
Climatic stations and Stever basin
areal rainfall

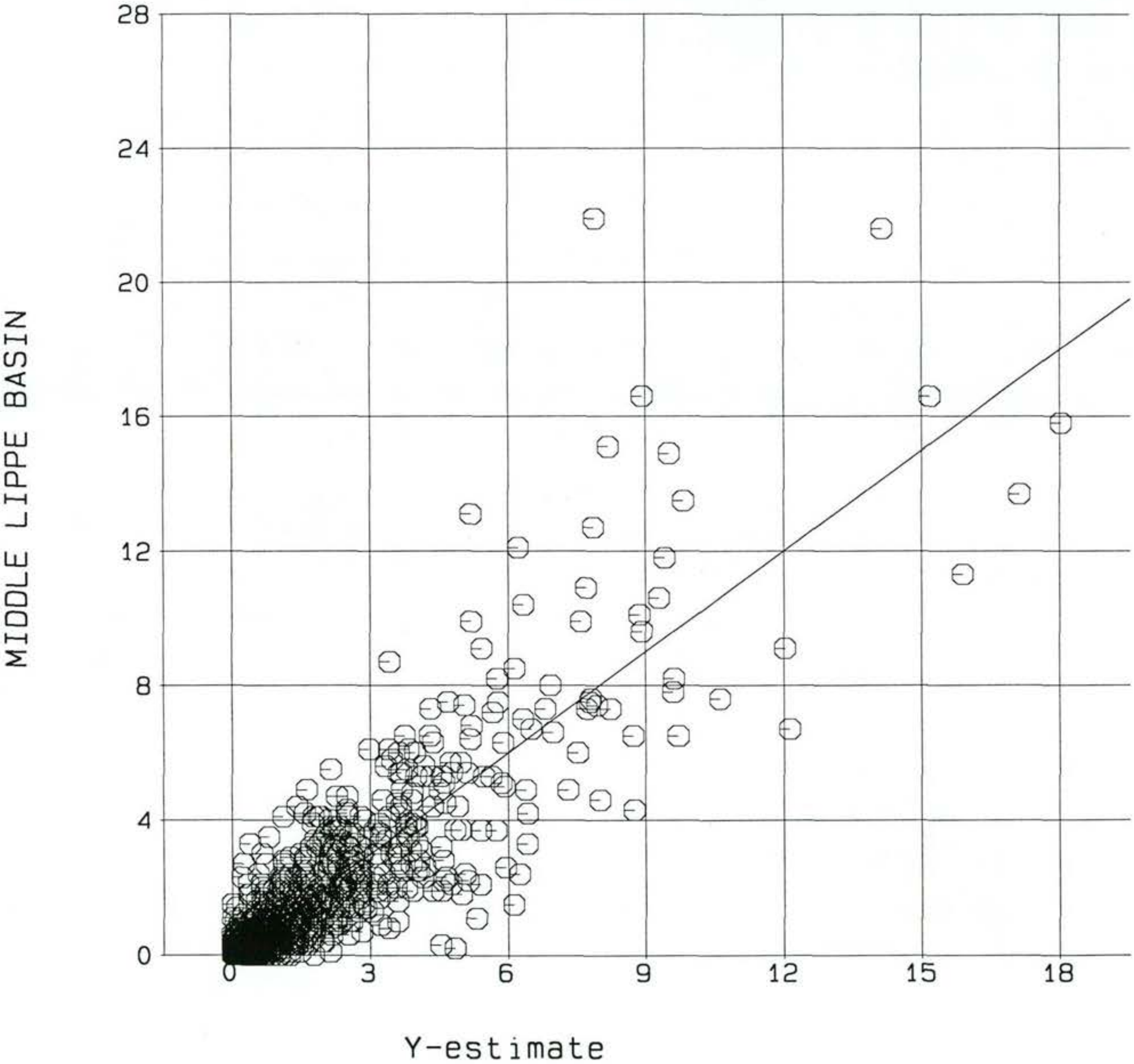
DELFT HYDRAULICS | R3049 | FIG. 7.2.3

Stepwise Regression

Regression coefficients :

Bad-Lippsp	.69888 E-01	Kahler-Ast	.56194 E-01
Bad-Salzuf	.69974 E-01	Luedenschd	.78421 E-01
Bocholt-L	.64599 E-01	Munster	.19385 E+00
Essen	.79887 E-01		
Guetersloh	.23258 E+00	Intercept	−.85884 E-03

See = .89248E+00



Multiple (step-wise) regression
Climatic stations and Middle Lippe
areal rainfall

DELFT HYDRAULICS | R3049 | FIG. 7.2.4

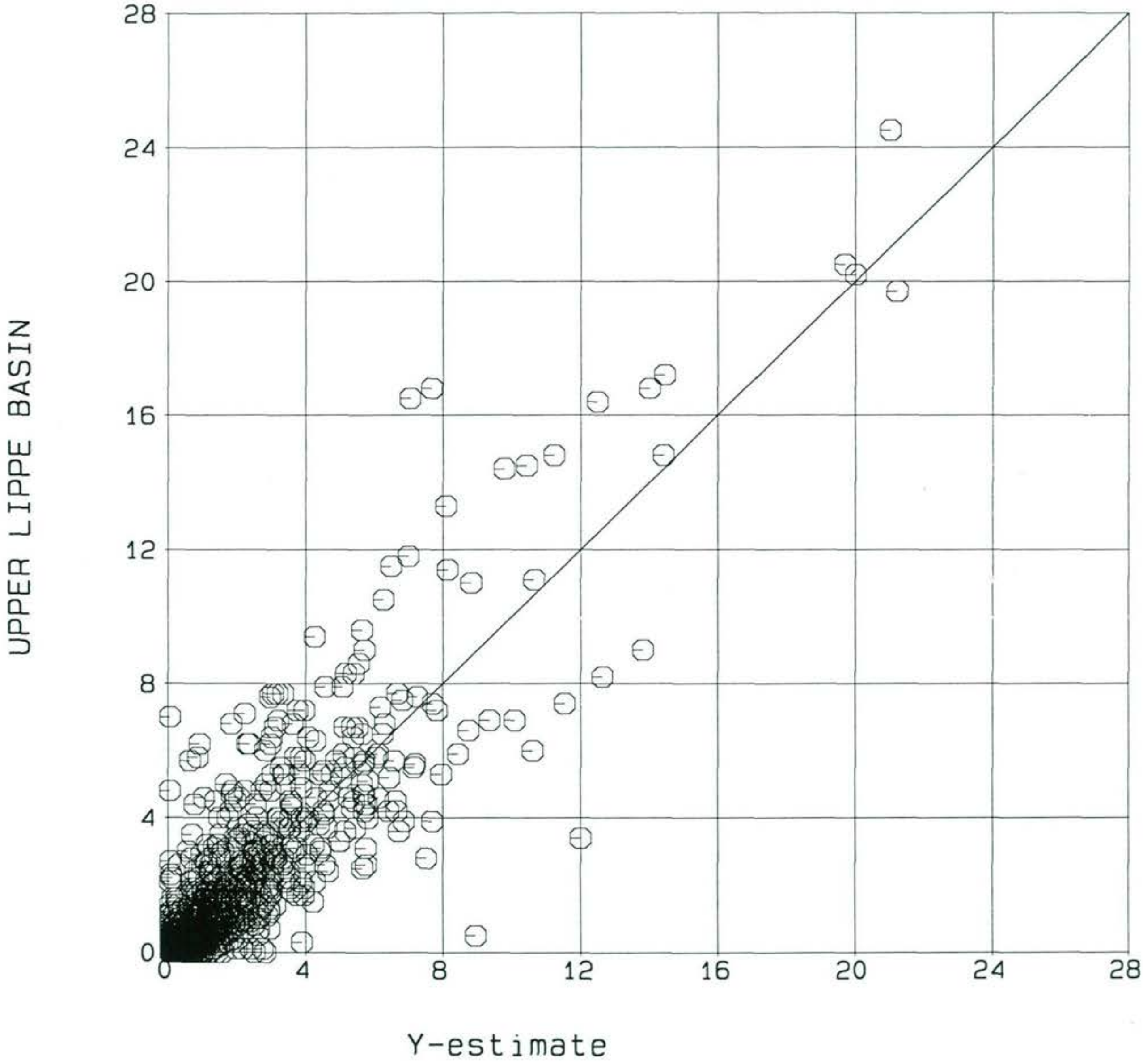
Stepwise Regression

Regression coefficients :

Bad-Lippspring	.39157E+00
Dusseldorf (Fl)	.59493E-01
Guetersloh	.22964E+00
Kahler-Asten	.13866E+00

Intercept = .52995E-01

See = .98363E+00



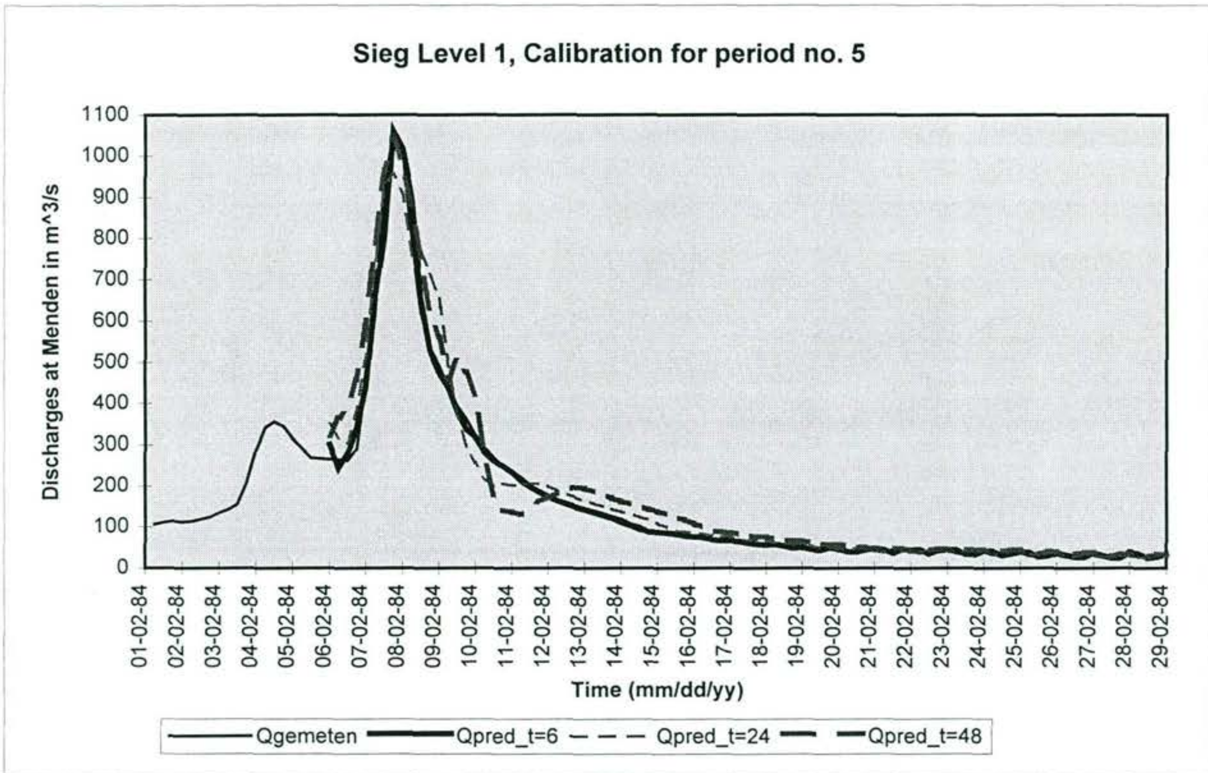
Multiple (step-wise) regression
Climatic stations and Upper Lippe
areal rainfall

DELFT HYDRAULICS | R3049 | FIG. 7.2.5

Figures of Chapter 9

SUMMARY OF CALIBRATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	7.8%	31.3%	-28.6%
12	13.1%	29.1%	-38.2%
18	14.0%	26.6%	-40.8%
24	13.7%	25.8%	-37.0%
30	18.2%	31.4%	-45.1%
36	22.9%	35.8%	-52.2%
42	24.4%	38.8%	-58.4%
48	25.0%	43.8%	-65.2%

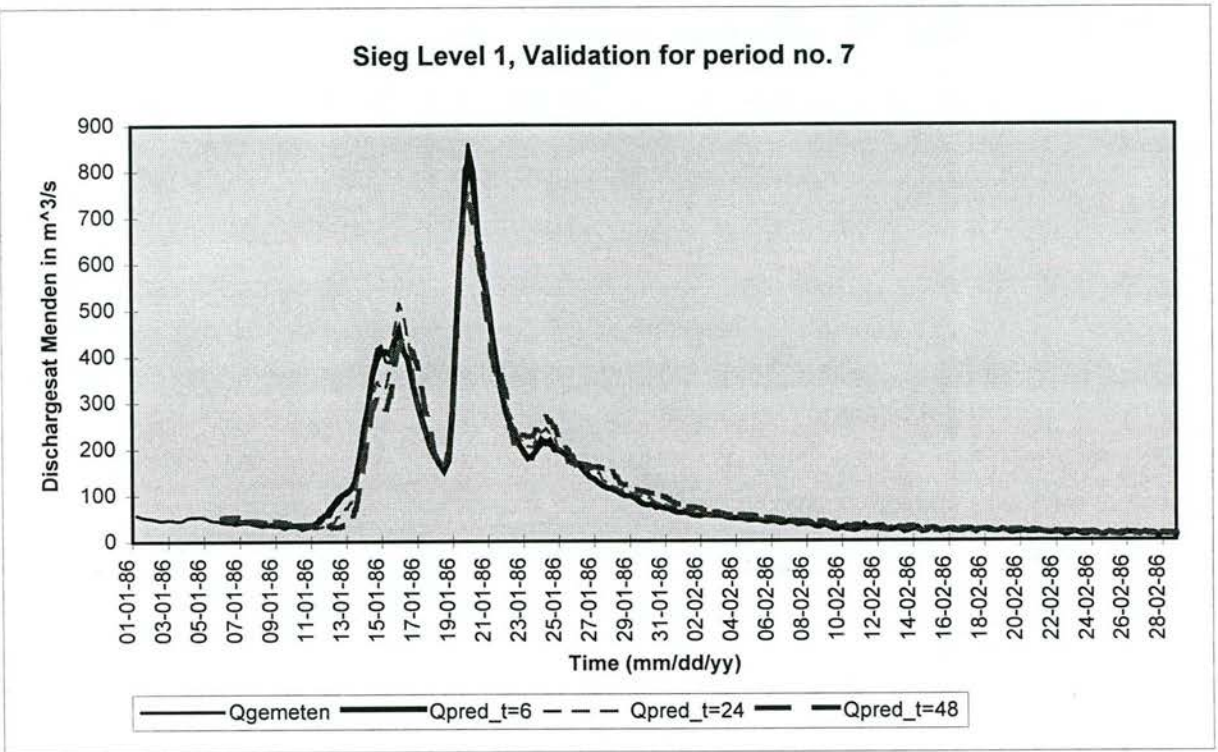


Model parameters			
fmin	0.30	alfa (1,1)	0.29
fmax	5.00	alfa (1,2)	0.14
kb	8.60	alfa (1,3)	0.10
psi	0.93	alfa (1,4)	0.00
kn	10.50	alfa (1,5)	0.00
nn	2.95	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00

Fig. 9.1. Sieg at Menden, Sieg Level 1, Total Sieg basin, Calibration for Period no. 5

SUMMARY OF VALIDATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	6.9%	36.1%	-40.9%
12	10.7%	31.3%	-43.5%
18	11.2%	41.1%	-60.7%
24	10.8%	49.1%	-33.3%
30	14.6%	56.4%	-55.6%
36	17.7%	60.1%	-58.3%
42	18.5%	65.4%	-54.5%
48	18.4%	67.7%	-45.1%

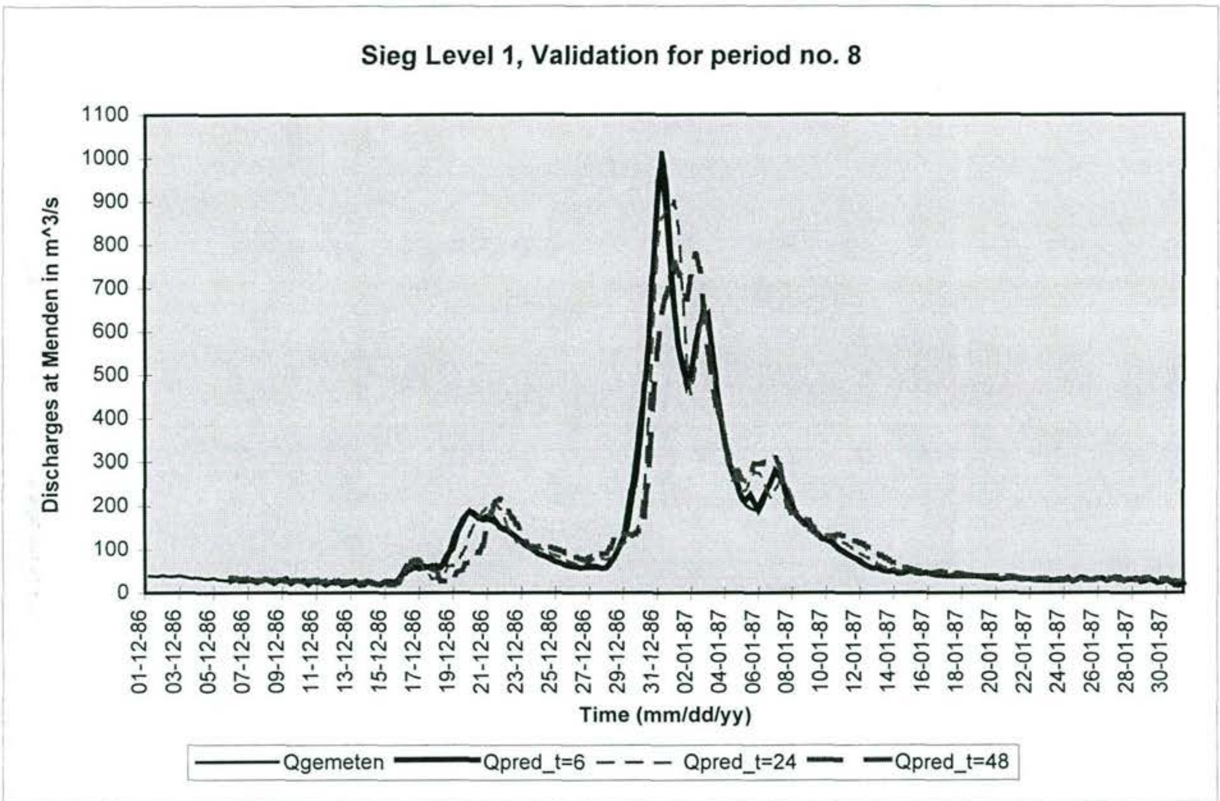


Model parameters			
fmin	0.30	alfa (1,1)	0.29
fmax	5.00	alfa (1,2)	0.14
kb	8.60	alfa (1,3)	0.10
psi	0.93	alfa (1,4)	0.00
kn	10.50	alfa (1,5)	0.00
nn	2.95	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00

Fig. 9.2. Sieg at Menden, Sieg Level 1, Total Sieg basin, Validation for Period no. 7

SUMMARY OF VALIDATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	7.0%	24.5%	-40.3%
12	11.6%	39.4%	-61.9%
18	13.8%	51.6%	-69.1%
24	14.9%	59.7%	-46.5%
30	18.5%	63.2%	-50.8%
36	21.2%	65.3%	-73.3%
42	22.6%	68.8%	-75.4%
48	23.4%	71.8%	-79.4%

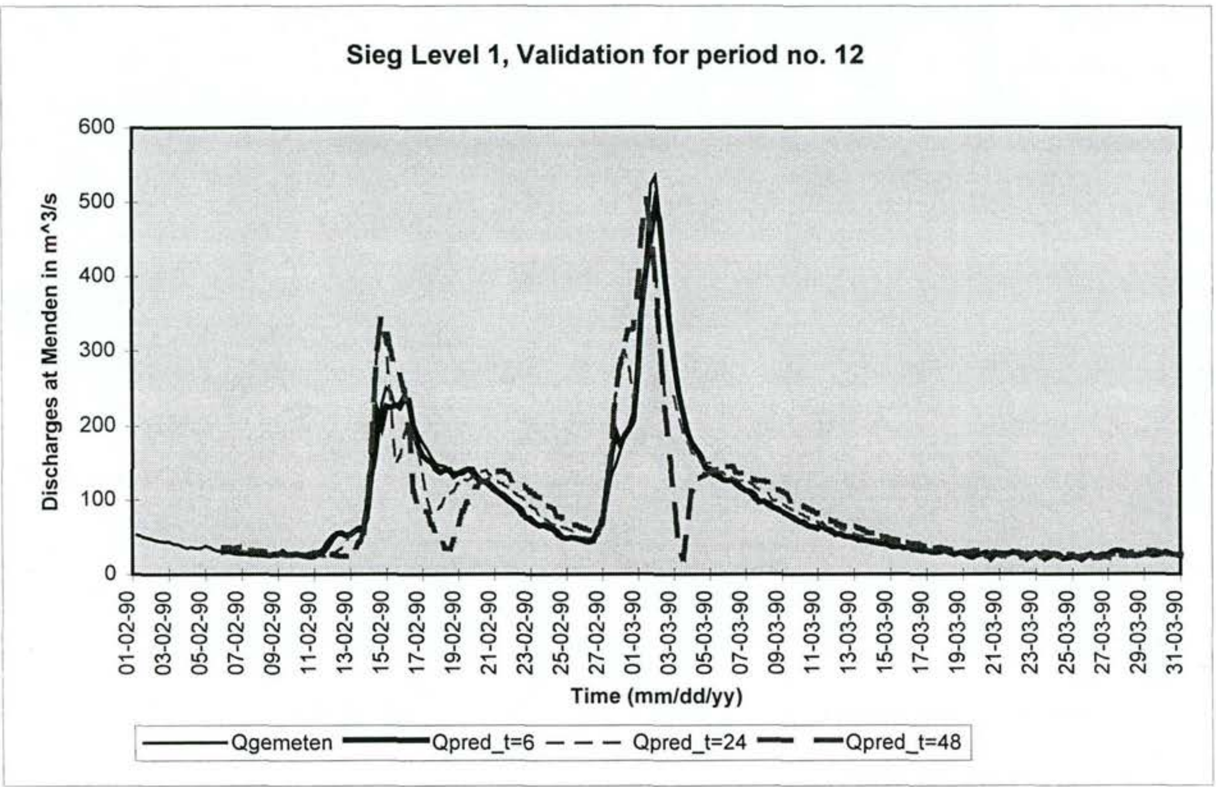


Model parameters			
fmin	0.30	alfa (1,1)	0.29
fmax	5.00	alfa (1,2)	0.14
kb	8.60	alfa (1,3)	0.10
psi	0.93	alfa (1,4)	0.00
kn	10.50	alfa (1,5)	0.00
nn	2.95	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00

Fig. 9.3. Sieg at Menden, Sieg Level 1, Total Sieg basin, Validation for Period no. 8

SUMMARY OF VALIDATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	5.4%	18.0%	-28.9%
12	9.5%	32.3%	-56.9%
18	12.3%	42.0%	-69.8%
24	15.1%	46.9%	-72.1%
30	18.3%	56.5%	-73.8%
36	21.5%	65.3%	-74.1%
42	24.3%	77.6%	-73.1%
48	26.7%	90.4%	-72.7%

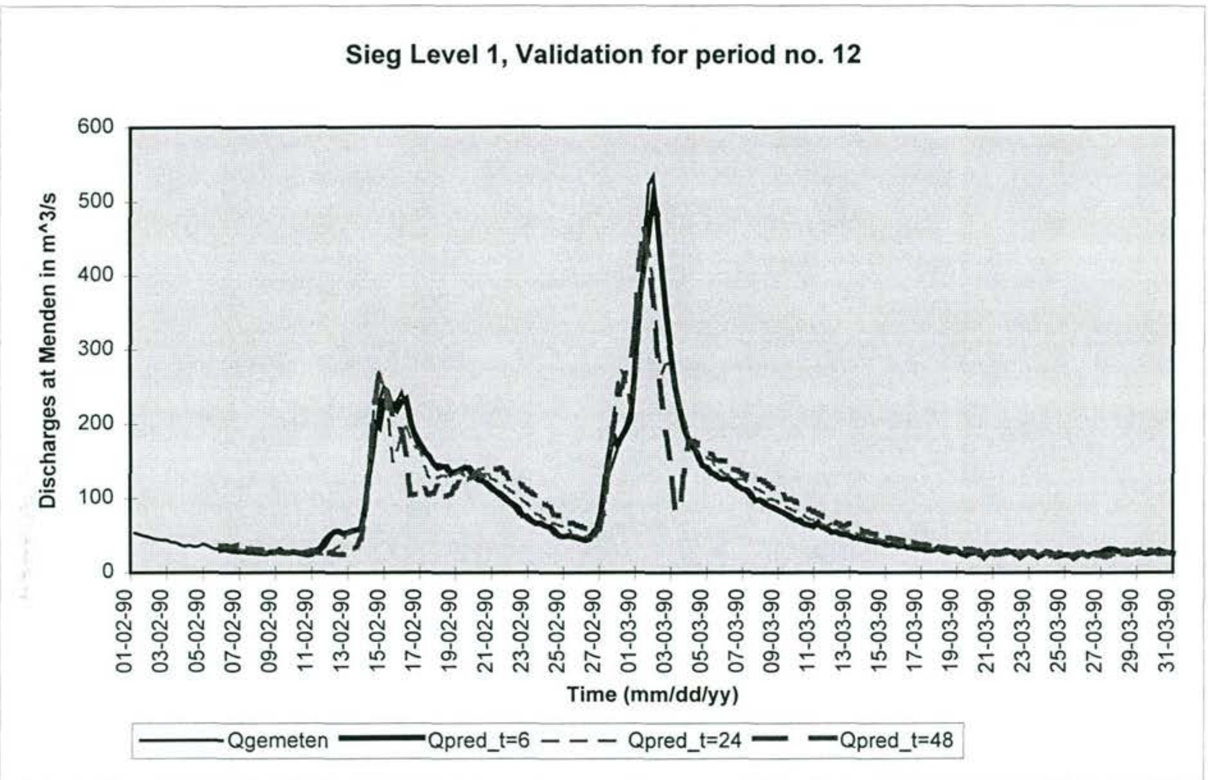


Model parameters			
fmin	0.30	alfa (1,1)	0.29
fmax	5.00	alfa (1,2)	0.14
kb	8.60	alfa (1,3)	0.10
psi	0.93	alfa (1,4)	0.00
kn	10.50	alfa (1,5)	0.00
nn	2.95	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00

Fig. 9.4 Sieg at Menden, Sieg Level 1, Total Sieg basin, Validation for Period no. 12 (fmin=0.30).

SUMMARY OF VALIDATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	5.0%	23.0%	-27.5%
12	8.6%	32.3%	-44.9%
18	10.9%	42.0%	-49.8%
24	13.2%	46.1%	-50.9%
30	15.9%	53.7%	-48.4%
36	18.6%	56.0%	-45.5%
42	21.0%	56.0%	-54.0%
48	23.0%	64.8%	-61.0%

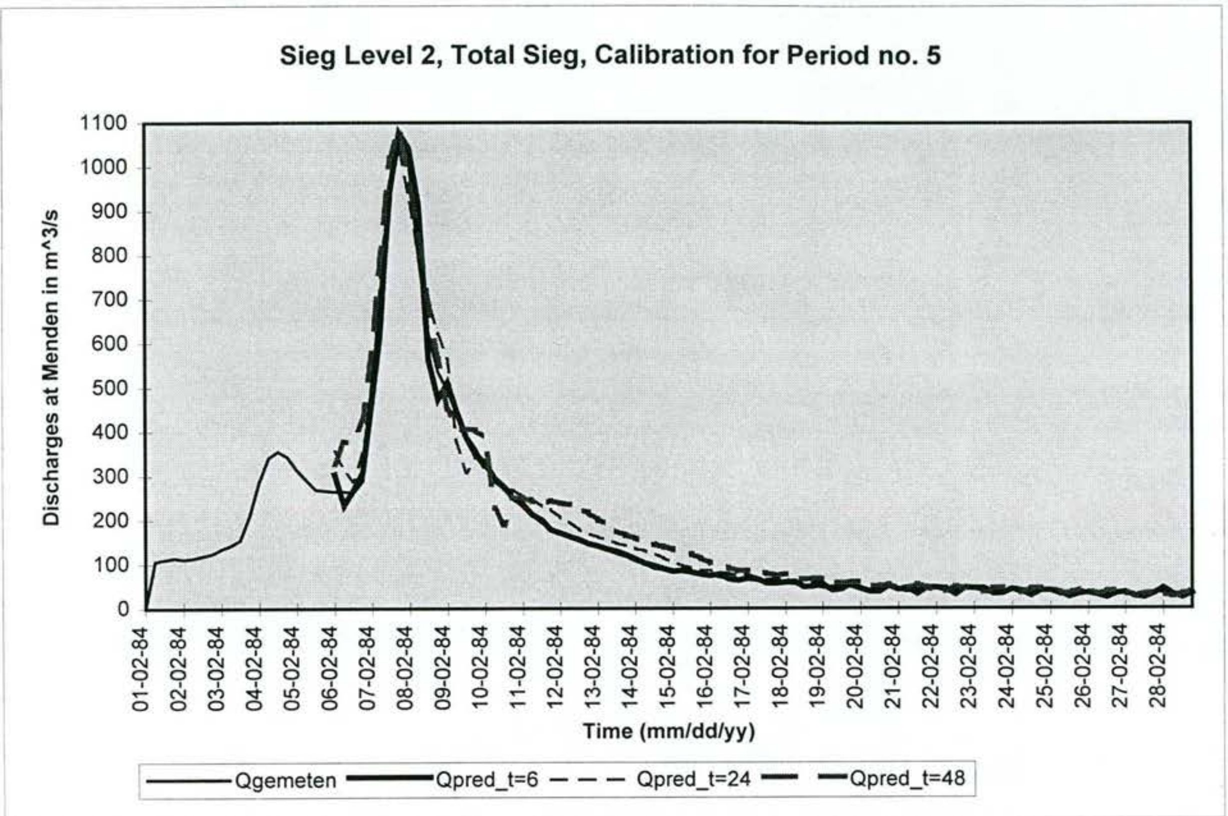


Model parameters			
fmin	0.40	alfa (1,1)	0.29
fmax	5.00	alfa (1,2)	0.14
kb	8.60	alfa (1,3)	0.10
psi	0.93	alfa (1,4)	0.00
kn	10.50	alfa (1,5)	0.00
nn	2.95	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00

Fig. 9.5 Sieg at Menden, Sieg Level 1, Total Sieg basin, Validation for Period no. 12 (fmin=0.40).

SUMMARY OF CALIBRATION RESULTS:

Prediction in hours advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	7.2%	25.6%	-29.2%
24	13.4%	21.5%	-37.7%
48	25.0%	29.8%	-60.5%

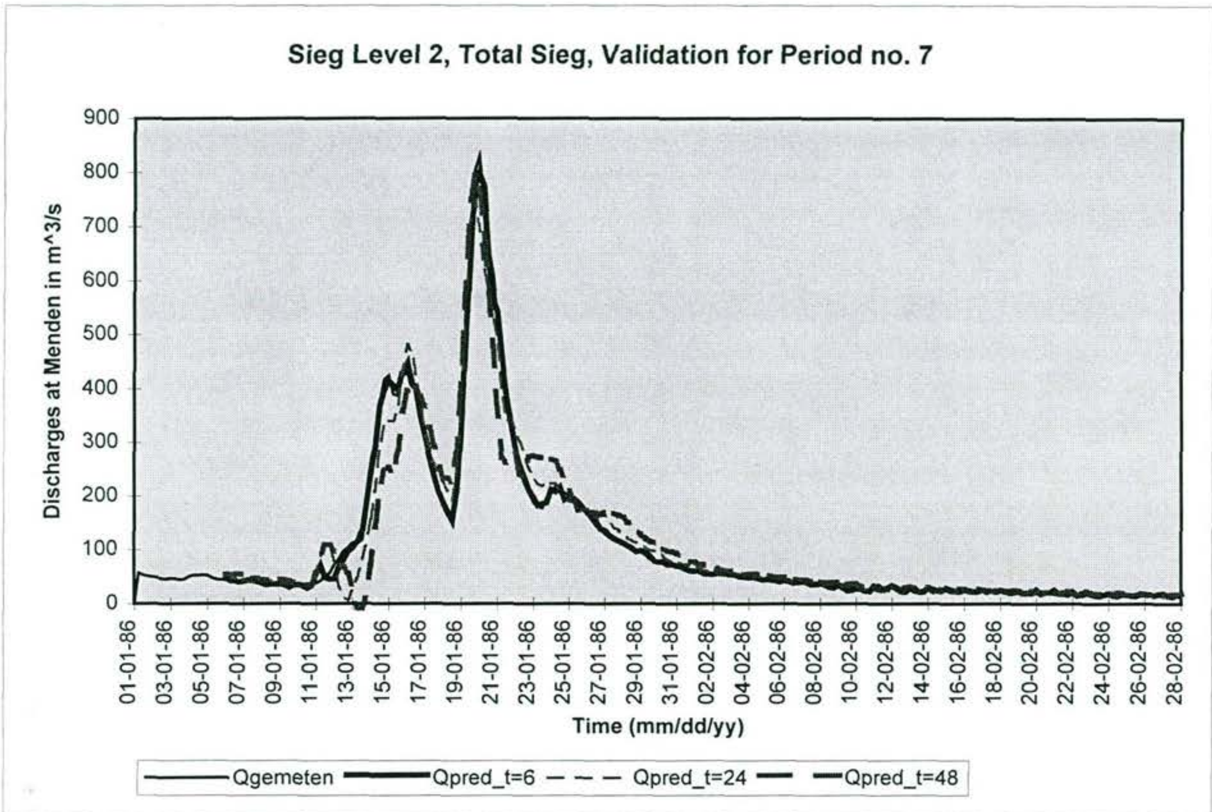


Model Parameters	Lower Sieg	Agger	Middle/Upper Sieg
fmin	0.01	0.54	0.40
fmax	5.00	5.00	5.00
kb	0.10	0.10	0.10
psi	1.00	0.89	0.94
kn	25.00	9.51	8.20
nn	2.60	2.10	3.50
alfa (1,1)	0.20	0.20	0.52
alfa (1,2)	0.00	0.00	0.41
alfa (1,3)	0.00	0.00	0.00
alfa (1,4)	0.00	0.00	0.00
alfa (1,5)	0.00	0.00	0.00
alfa (1,6)	0.00	0.00	0.00
alfa (1,7)	0.00	0.00	0.00
alfa (1.8)	0.00	0.00	0.00

Fig. 9.6. Sieg at Menden, Sieg Level 2, Total Sieg basin, Calibration for Period no. 5

SUMMARY OF VALIDATION RESULTS:

Prediction in hours advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	8.9%	35.9%	-66.5%
24	18.0%	93.8%	-110.5%
48	26.4%	108.3%	-111.7%

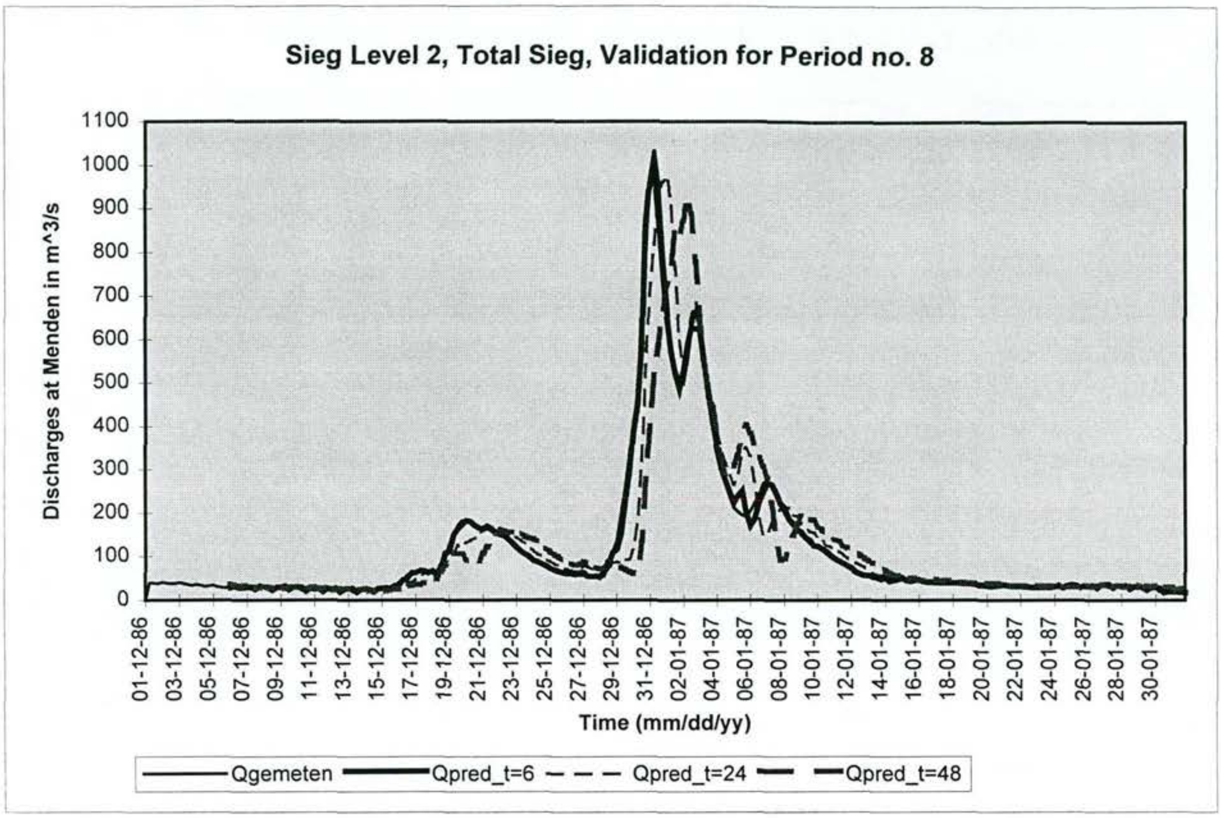


Model parameter	**Lower Sieg**	**Agger**	**Middle/Upper Sieg**
fmin	0.01	0.54	0.40
fmax	5.00	5.00	5.00
kb	0.10	0.10	0.10
psi	1.00	0.89	0.94
kn	25.00	9.51	8.20
nn	2.60	2.10	3.50
alfa (1,1)	0.20	0.20	0.52
alfa (1,2)	0.00	0.00	0.41
alfa (1,3)	0.00	0.00	0.00
alfa (1,4)	0.00	0.00	0.00
alfa (1,5)	0.00	0.00	0.00
alfa (1,6)	0.00	0.00	0.00
alfa (1,7)	0.00	0.00	0.00
alfa (1.8)	0.00	0.00	0.00

Fig. 9.7. Sieg at Menden, Sieg Level 2, Total Sieg basin, Validation for Period no. 7.

SUMMARY OF VALIDATION RESULTS:

Prediction in hours advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	6.0%	23.4%	-37.0%
24	16.9%	71.1%	-82.6%
48	28.6%	87.2%	-110.0%

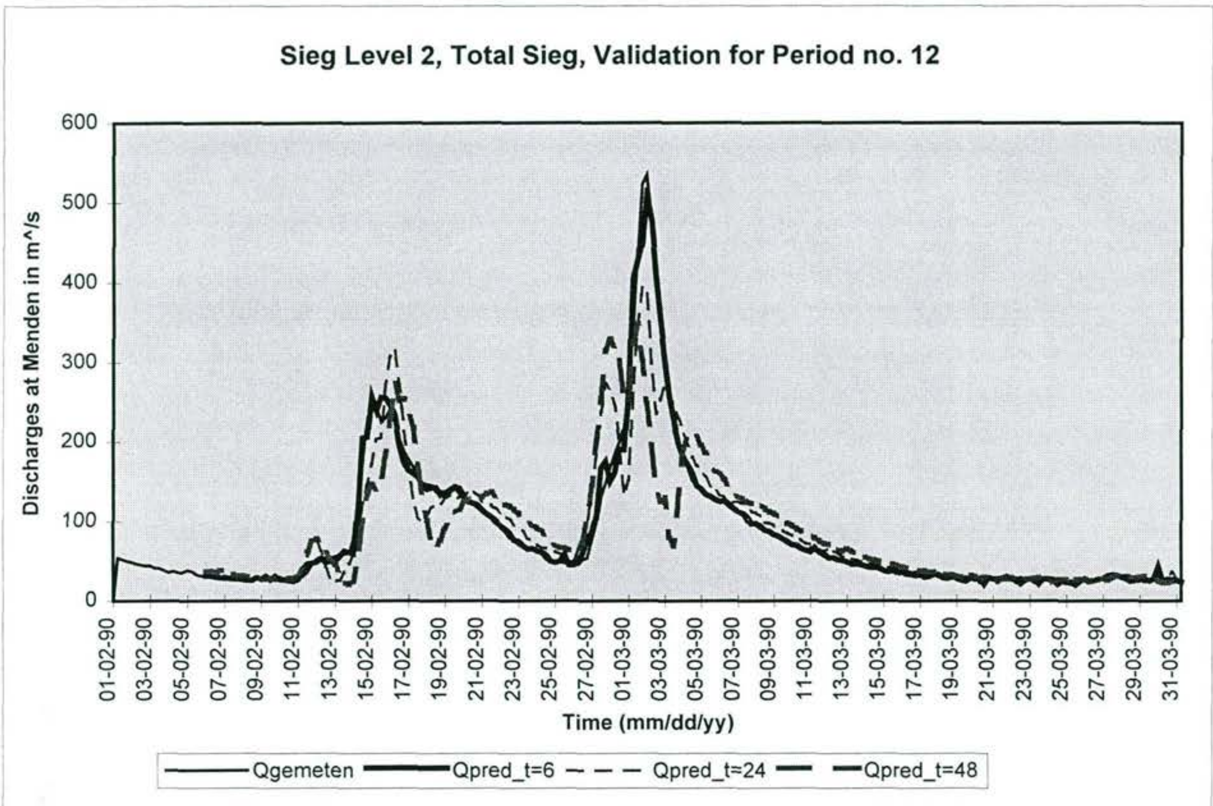


Model Parameters	**Lower Sieg**	**Agger**	**Middle/Upper Sieg**
fmin	0.01	0.54	0.40
fmax	5.00	5.00	5.00
kb	0.10	0.10	0.10
psi	1.00	0.89	0.94
kn	25.00	9.51	8.20
nn	2.60	2.10	3.50
alfa (1,1)	0.20	0.20	0.52
alfa (1,2)	0.00	0.00	0.41
alfa (1,3)	0.00	0.00	0.00
alfa (1,4)	0.00	0.00	0.00
alfa (1,5)	0.00	0.00	0.00
alfa (1,6)	0.00	0.00	0.00
alfa (1,7)	0.00	0.00	0.00
alfa (1.8)	0.00	0.00	0.00

Fig. 9.8 Sieg at Menden, Sieg Level 2, Total Sieg basin, Validation for Period no. 8

SUMMARY OF VALIDATION RESULTS:

Prediction in hours advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	5.7%	21.9%	-43.8%
24	17.7%	56.7%	-87.3%
48	27.9%	68.1%	-112.6%

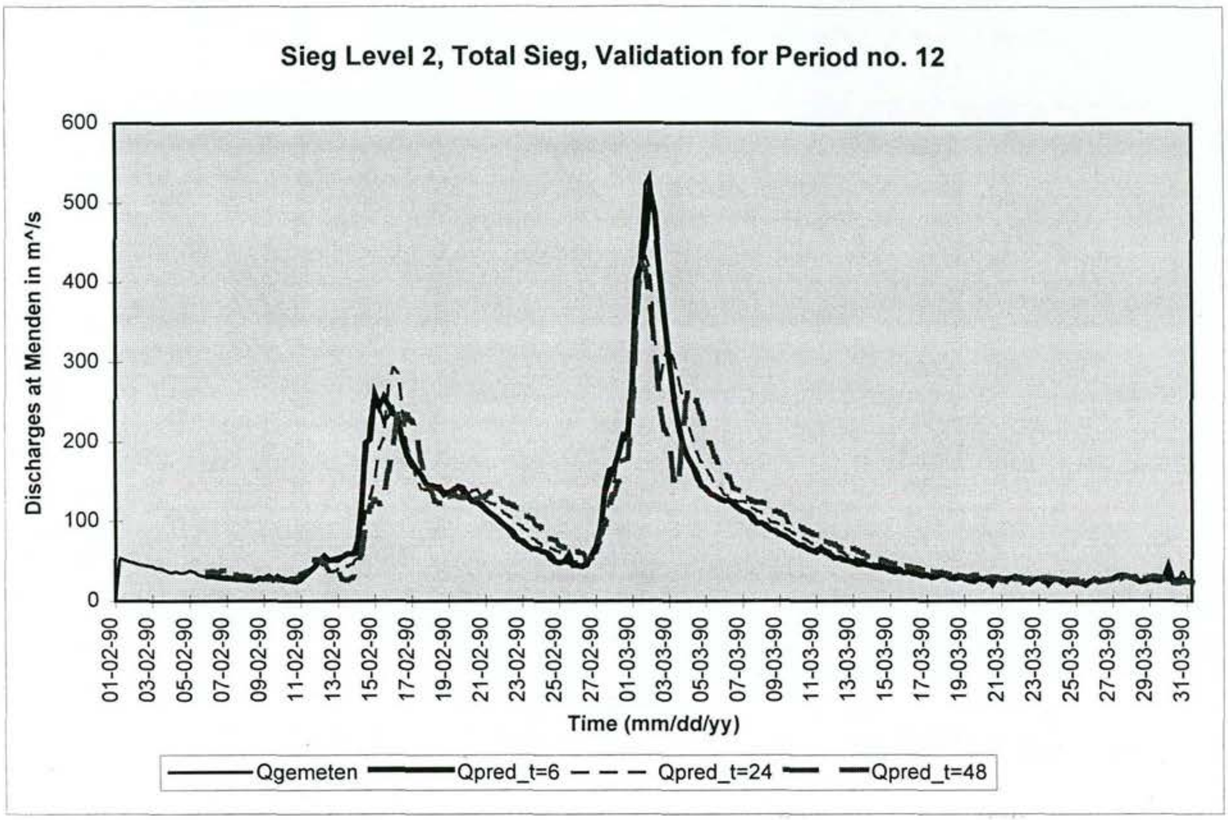


Model Parameters	**Lower Sieg**	**Agger**	**Middle/Upper Sieg**
fmin	0.01	0.54	0.40
fmax	5.00	5.00	5.00
kb	0.10	0.10	0.10
psi	1.00	0.89	0.94
kn	25.00	9.51	8.20
nn	2.60	2.10	3.50
alfa (1,1)	0.20	0.20	0.52
alfa (1,2)	0.00	0.00	0.41
alfa (1,3)	0.00	0.00	0.00
alfa (1,4)	0.00	0.00	0.00
alfa (1,5)	0.00	0.00	0.00
alfa (1,6)	0.00	0.00	0.00
alfa (1,7)	0.00	0.00	0.00
alfa (1.8)	0.00	0.00	0.00

Fig. 9.9. Sieg at Menden, Sieg Level 2, Total Sieg basin, Validation for Period no. 12 (fmin=0.40 for the Middle/Upper Sieg).

SUMMARY OF VALIDATION RESULTS:

Prediction in hours advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	4.8%	20.5%	-43.3%
24	13.6%	42.6%	-39.3%
48	22.9%	55.8%	-66.5%

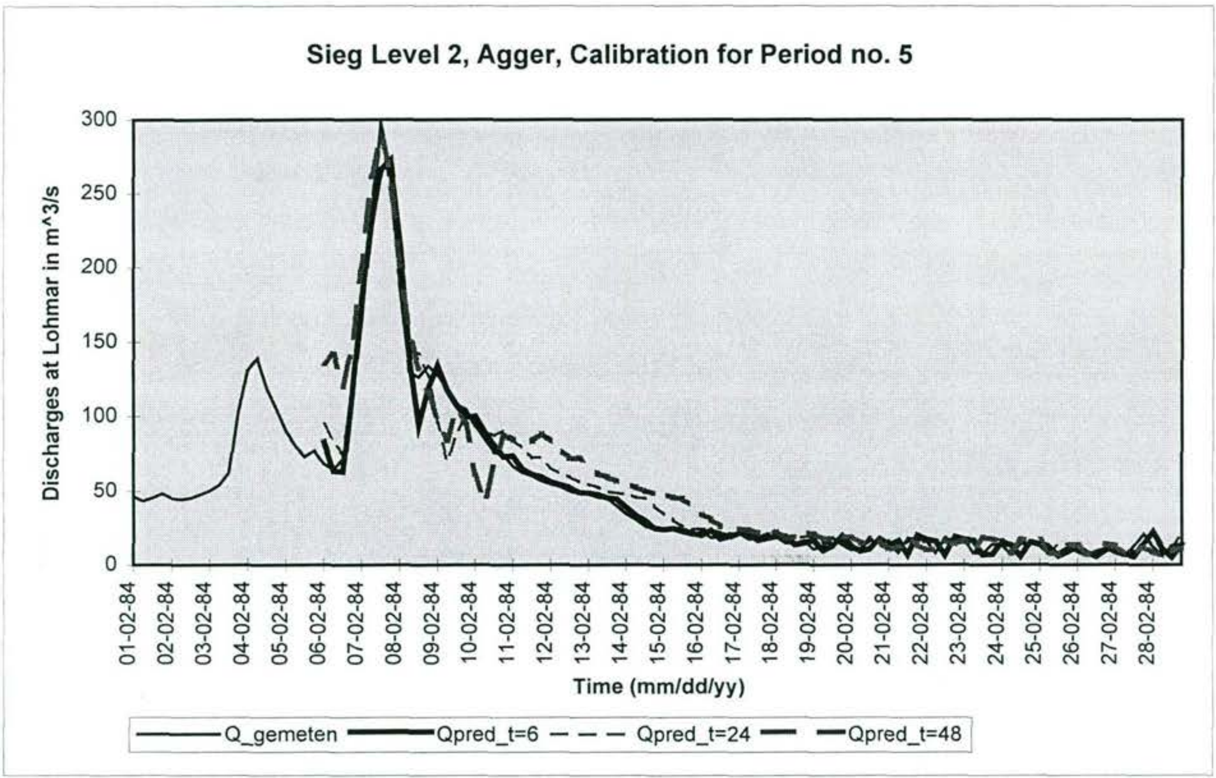


Model Parameters	**Lower Sieg**	**Agger**	**Middle/Upper Sieg**
fmin	0.01	0.54	0.70
fmax	5.00	5.00	5.00
kb	0.10	0.10	0.10
psi	1.00	0.89	0.94
kn	25.00	9.51	8.20
nn	2.60	2.10	3.50
alfa (1,1)	0.20	0.20	0.52
alfa (1,2)	0.00	0.00	0.41
alfa (1,3)	0.00	0.00	0.00
alfa (1,4)	0.00	0.00	0.00
alfa (1,5)	0.00	0.00	0.00
alfa (1,6)	0.00	0.00	0.00
alfa (1,7)	0.00	0.00	0.00
alfa (1.8)	0.00	0.00	0.00

Fig. 9.10. Sieg at Menden, Sieg Level 2, Total Sieg basin, Validation for Period no. 12 (fmin=0.70 for the Middle/Upper Sieg).

SUMMARY OF CALIBRATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	21.6%	62.0%	-102.4%
12	28.7%	71.7%	-222.4%
18	26.9%	62.3%	-134.6%
24	20.4%	48.1%	-135.4%
30	30.8%	54.6%	-136.2%
36	38.9%	70.7%	-141.1%
42	39.8%	57.6%	-142.0%
48	37.0%	50.4%	-149.6%

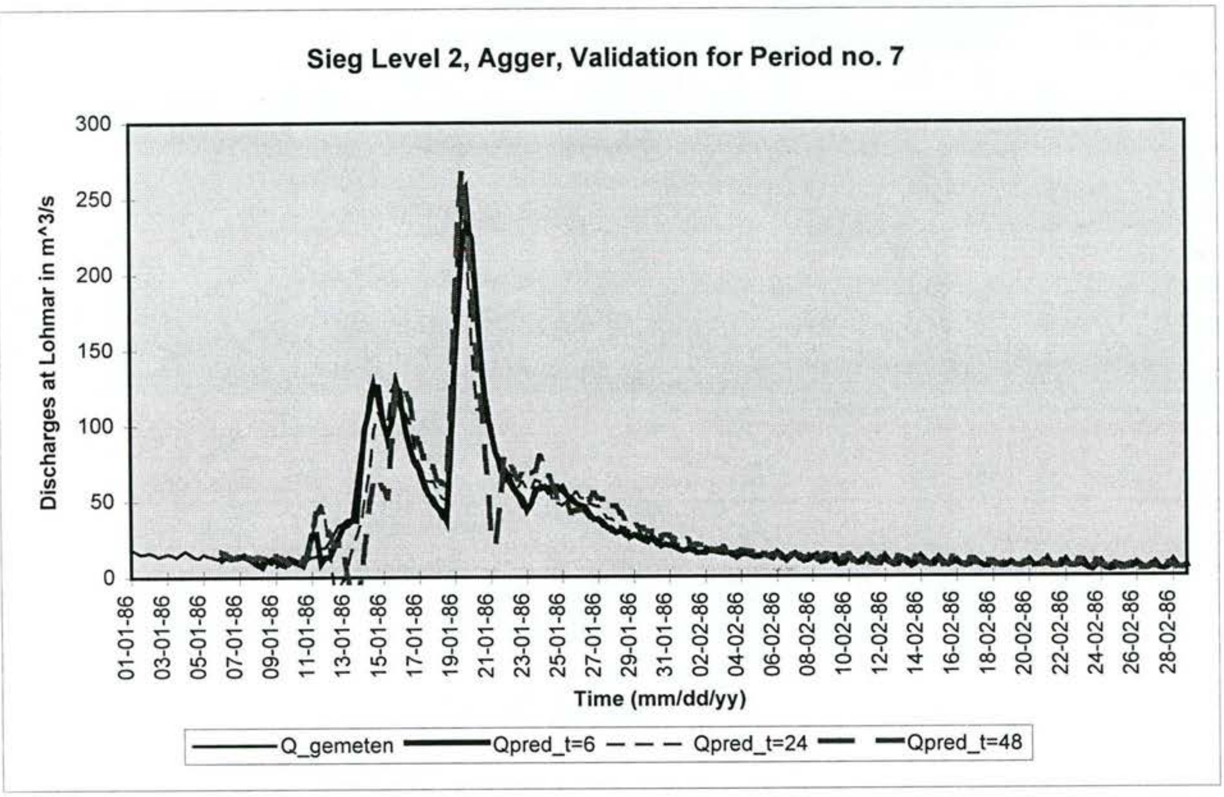


Model parameters			
fmin	0.54	alfa (1,1)	0.20
fmax	5.00	alfa (1,2)	0.00
kb	0.10	alfa (1,3)	0.00
psi	0.89	alfa (1,4)	0.00
kn	9.51	alfa (1,5)	0.00
nn	2.10	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00

Fig. 9.11. Agger at Lohmar, Sieg Level 2, Agger basin, Calibration for Period no. 5.

SUMMARY OF VALIDATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	15.6%	50.5%	-110.6%
12	22.4%	81.8%	-235.9%
18	21.5%	107.6%	-248.4%
24	17.9%	127.9%	-208.1%
30	25.0%	136.3%	-221.9%
36	30.0%	143.4%	-230.5%
42	28.3%	145.8%	-233.6%
48	25.6%	149.0%	-207.2%

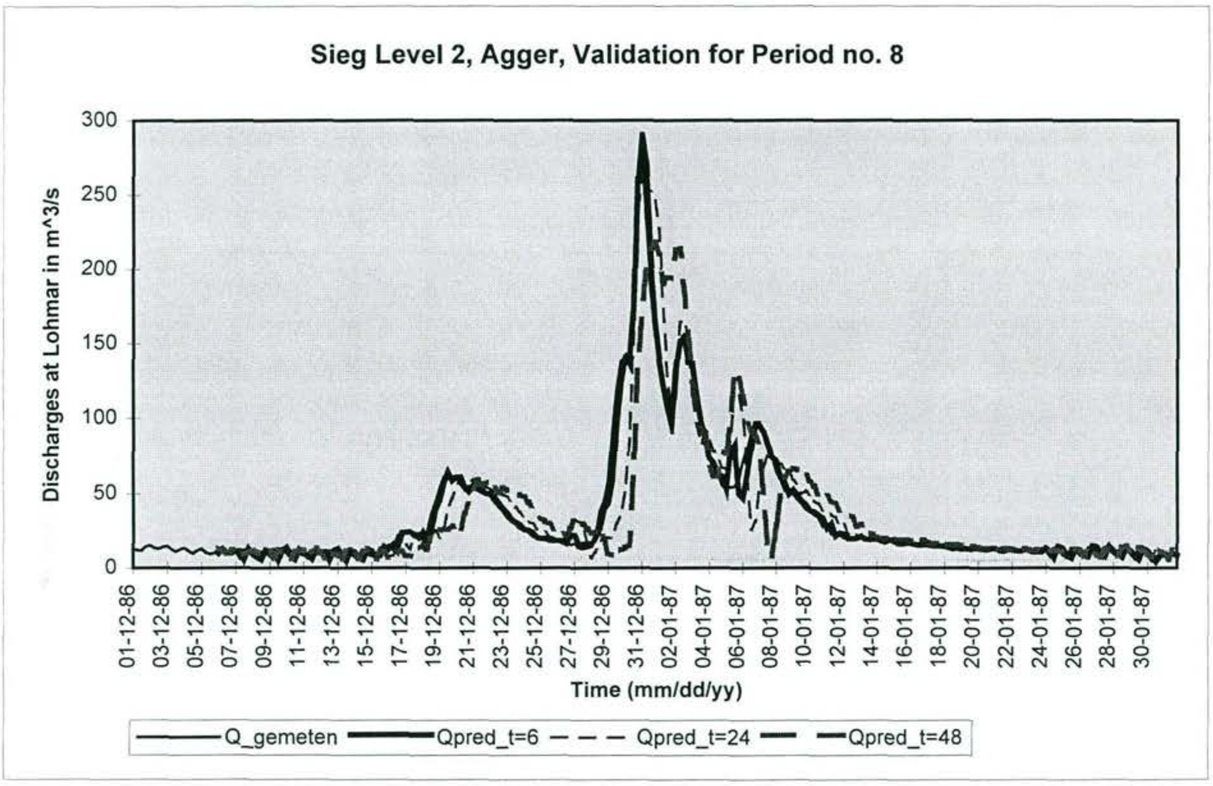


Model parameters			
fmin	0.54	alfa (1,1)	0.20
fmax	5.00	alfa (1,2)	0.00
kb	0.10	alfa (1,3)	0.00
psi	0.89	alfa (1,4)	0.00
kn	9.51	alfa (1,5)	0.00
nn	2.10	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00

Fig. 9.12. Agger at Lohmar, Sieg Level 2, Agger basin, Validation for Period no. 7

SUMMARY OF VALIDATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	14.4%	54.4%	-78.7%
12	21.8%	59.2%	-130.8%
18	22.9%	68.5%	-138.9%
24	21.0%	78.2%	-119.6%
30	29.4%	84.9%	-121.5%
36	34.0%	88.0%	-137.8%
42	34.5%	89.5%	-151.2%
48	33.3%	92.0%	-139.2%

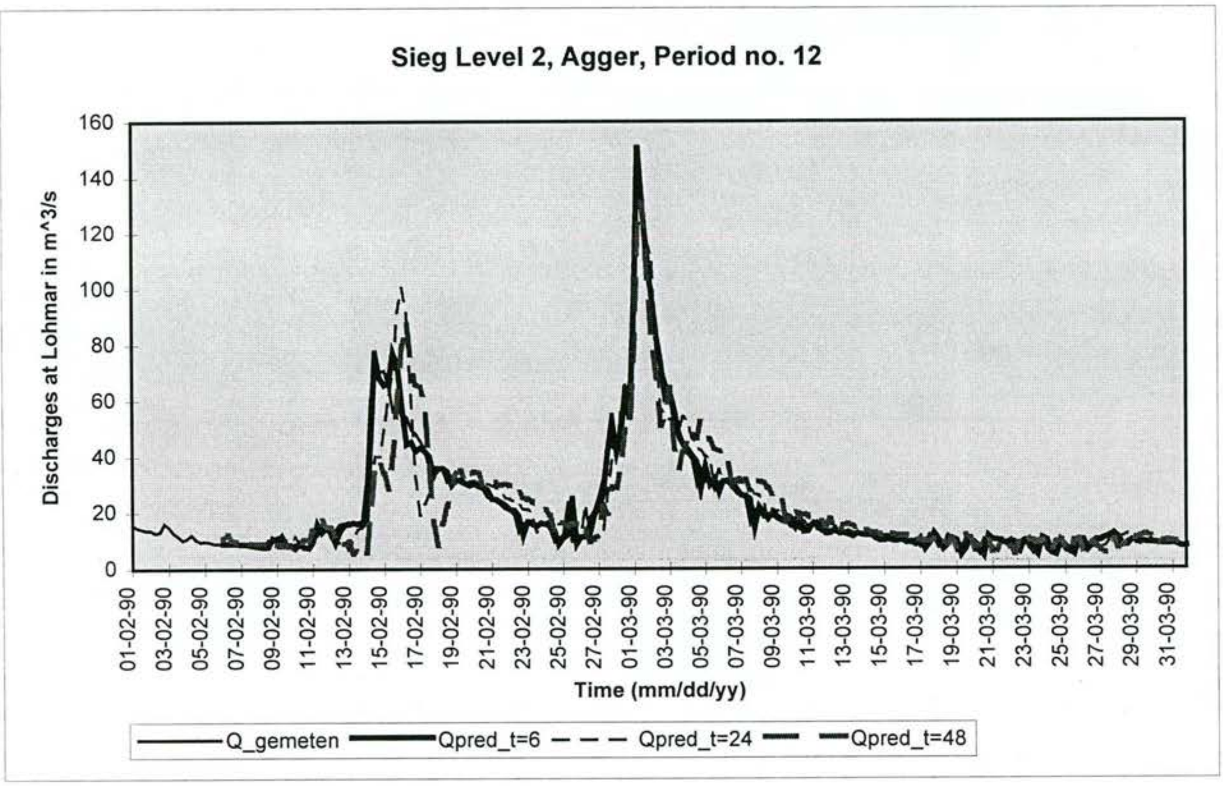


Model parametres			
fmin	0.54	alfa (1,1)	0.20
fmax	5.00	alfa (1,2)	0.00
kb	0.10	alfa (1,3)	0.00
psi	0.89	alfa (1,4)	0.00
kn	9.51	alfa (1,5)	0.00
nn	2.10	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00

Fig. 9.13. Agger at Lohmar, Sieg Level 2, Agger basin, Validation for Period no. 8.

SUMMARY OF VALIDATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	12.4%	54.7%	-119.8%
12	17.6%	53.4%	-100.9%
18	18.5%	57.5%	-100.9%
24	18.6%	60.9%	-84.2%
30	22.5%	66.1%	-86.3%
36	26.3%	68.3%	-104.9%
42	26.6%	73.6%	-97.9%
48	26.4%	81.1%	-115.5%

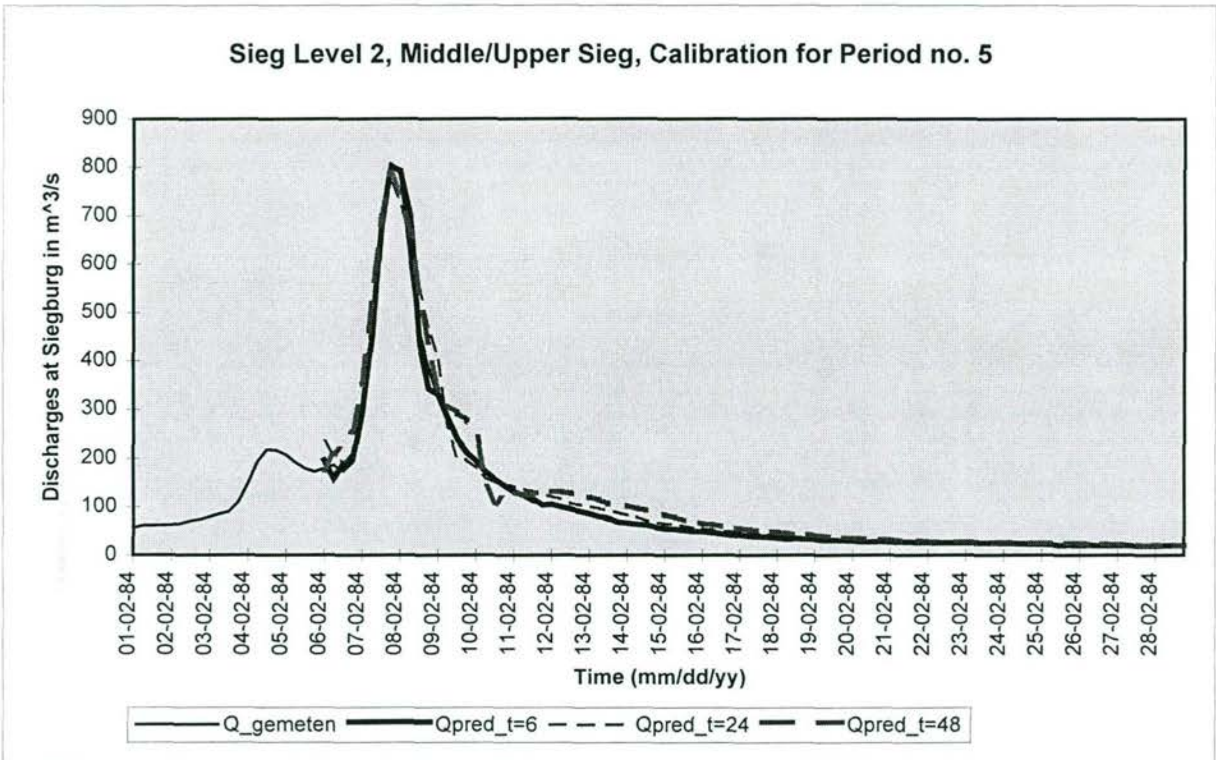


Model parameters			
fmin	0.54	alfa (1,1)	0.20
fmax	5.00	alfa (1,2)	0.00
kb	0.10	alfa (1,3)	0.00
psi	0.89	alfa (1,4)	0.00
kn	9.51	alfa (1,5)	0.00
nn	2.10	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00

Fig. 9.14. Agger at Lohmar, Sieg Level 2, Agger basin, Validation for Period no. 12.

SUMMARY OF CALIBRATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	2.6%	14.8%	-16.3%
12	5.1%	15.1%	-26.6%
18	8.4%	13.9%	-23.7%
24	11.2%	17.3%	-30.6%
30	14.1%	22.8%	-36.9%
36	17.0%	26.2%	-43.2%
42	19.7%	29.1%	-49.7%
48	22.2%	30.7%	-57.3%

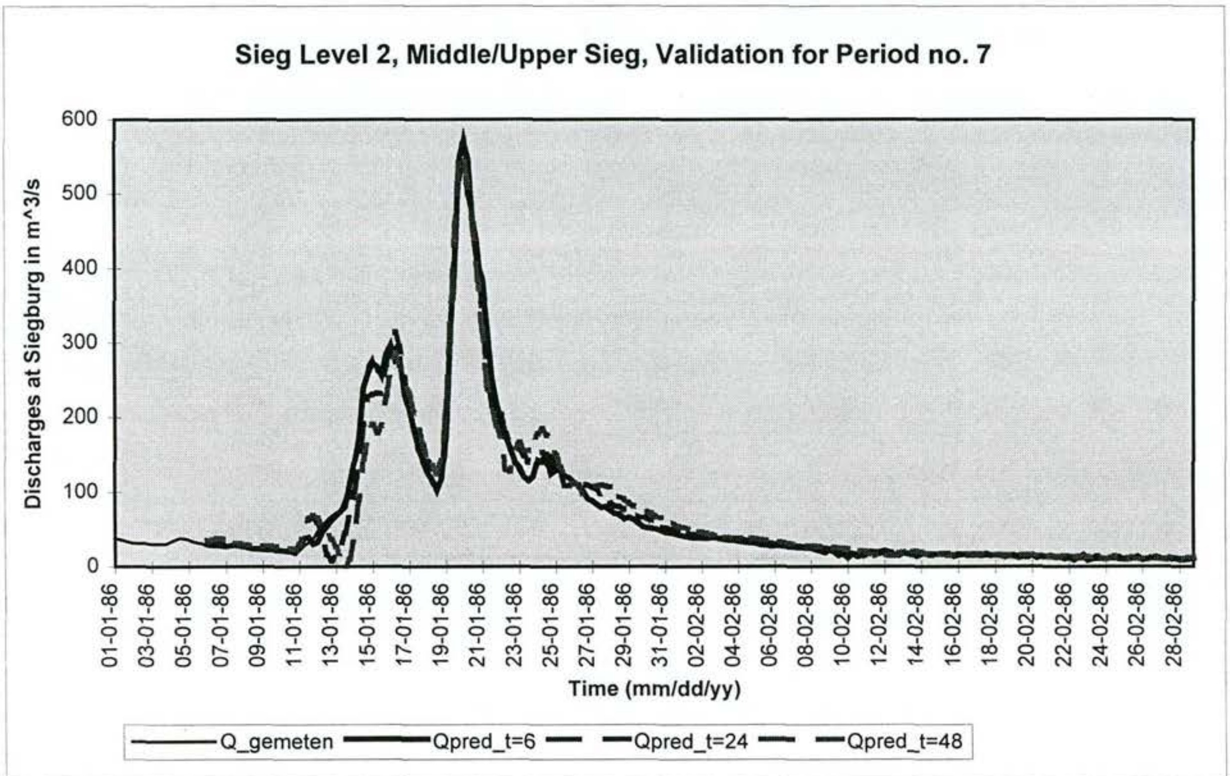


Model parameters			
fmin	0.40	alfa (1,1)	0.52
fmax	5.00	alfa (1,2)	0.41
kb	0.10	alfa (1,3)	0.00
psi	0.94	alfa (1,4)	0.00
kn	8.20	alfa (1,5)	0.00
nn	3.50	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00

Fig. 9.15. Sieg at Siegburg, Sieg Level 2, Middle/Upper Sieg basin, Calibration for Period no. 5.

SUMMARY OF VALIDATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	5.8%	29.9%	-47.3%
12	8.6%	55.3%	-73.7%
18	11.5%	74.7%	-90.6%
24	13.7%	88.5%	-91.0%
30	16.3%	97.6%	-95.4%
36	18.4%	103.3%	-97.0%
42	20.0%	103.0%	-99.1%
48	21.1%	100.9%	-100.3%

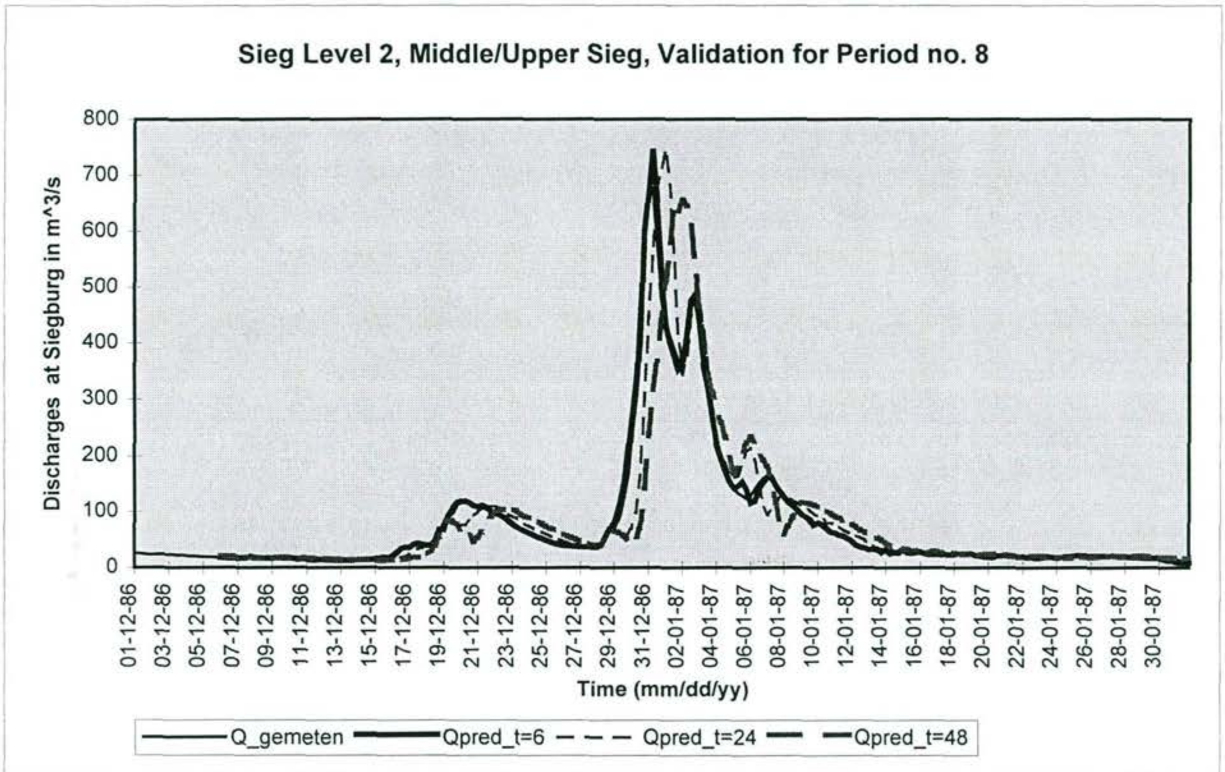


Model parameters			
fmin	0.40	alfa (1,1)	0.52
fmax	5.00	alfa (1,2)	0.41
kb	0.10	alfa (1,3)	0.00
psi	0.94	alfa (1,4)	0.00
kn	8.20	alfa (1,5)	0.00
nn	3.50	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00

Fig. 9.16. Sieg at Siegburg, Sieg Level 2, Middle/Upper Sieg basin, Validation for Period no. 7.

SUMMARY OF VALIDATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	4.1%	22.7%	-19.9%
12	8.4%	45.2%	-48.7%
18	13.5%	65.9%	-65.5%
24	17.0%	75.1%	-72.0%
30	20.5%	80.9%	-79.5%
36	23.5%	85.3%	-84.3%
42	26.4%	85.6%	-87.0%
48	29.1%	86.5%	-91.6%

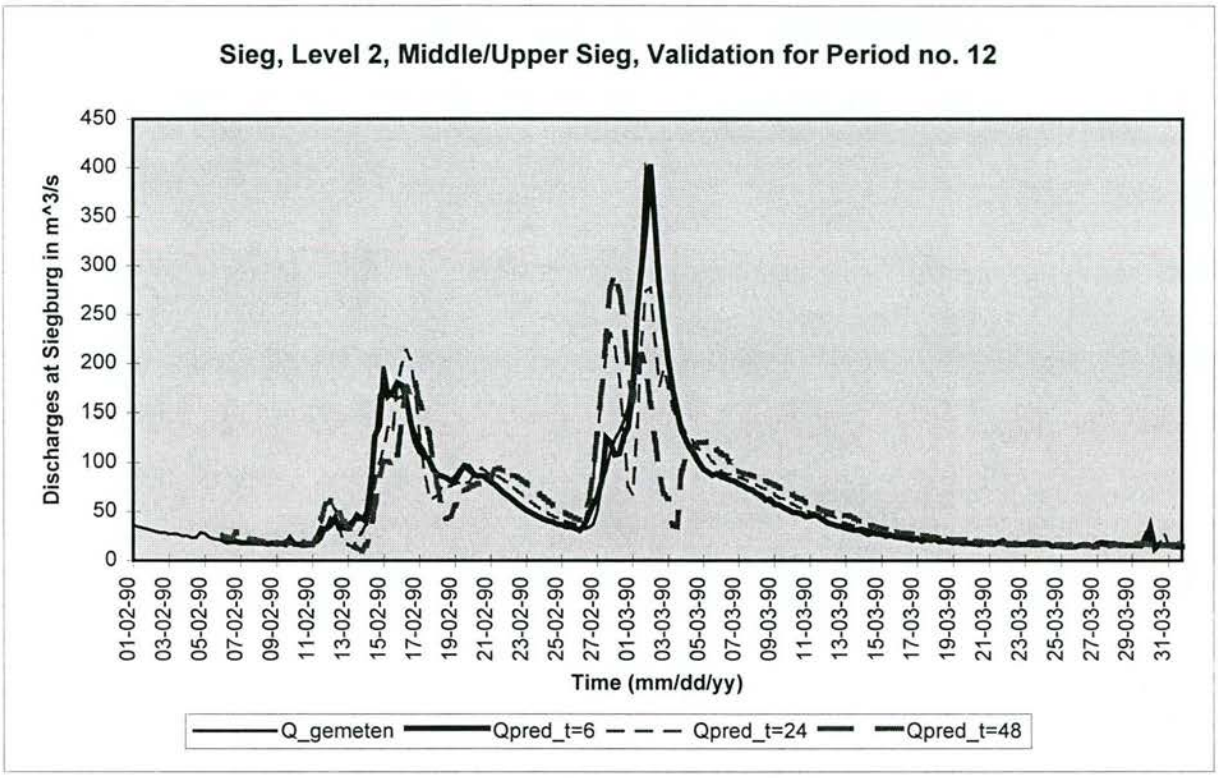


Model parameters			
fmin	0.40	alfa (1,1)	0.52
fmax	5.00	alfa (1,2)	0.41
kb	0.10	alfa (1,3)	0.00
psi	0.94	alfa (1,4)	0.00
kn	8.20	alfa (1,5)	0.00
nn	3.50	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00

Fig. 9.17. Sieg at Siegburg, Sieg Level 2, Middle/Upper Sieg basin, Validation for Period no. 8

SUMMARY OF VALIDATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	5.6%	33.7%	-86.4%
12	10.4%	44.7%	-111.1%
18	15.6%	54.6%	-142.7%
24	19.4%	67.9%	-149.9%
30	22.9%	71.3%	-151.0%
36	25.7%	83.1%	-154.4%
42	28.2%	81.0%	-156.7%
48	30.5%	79.2%	-158.2%

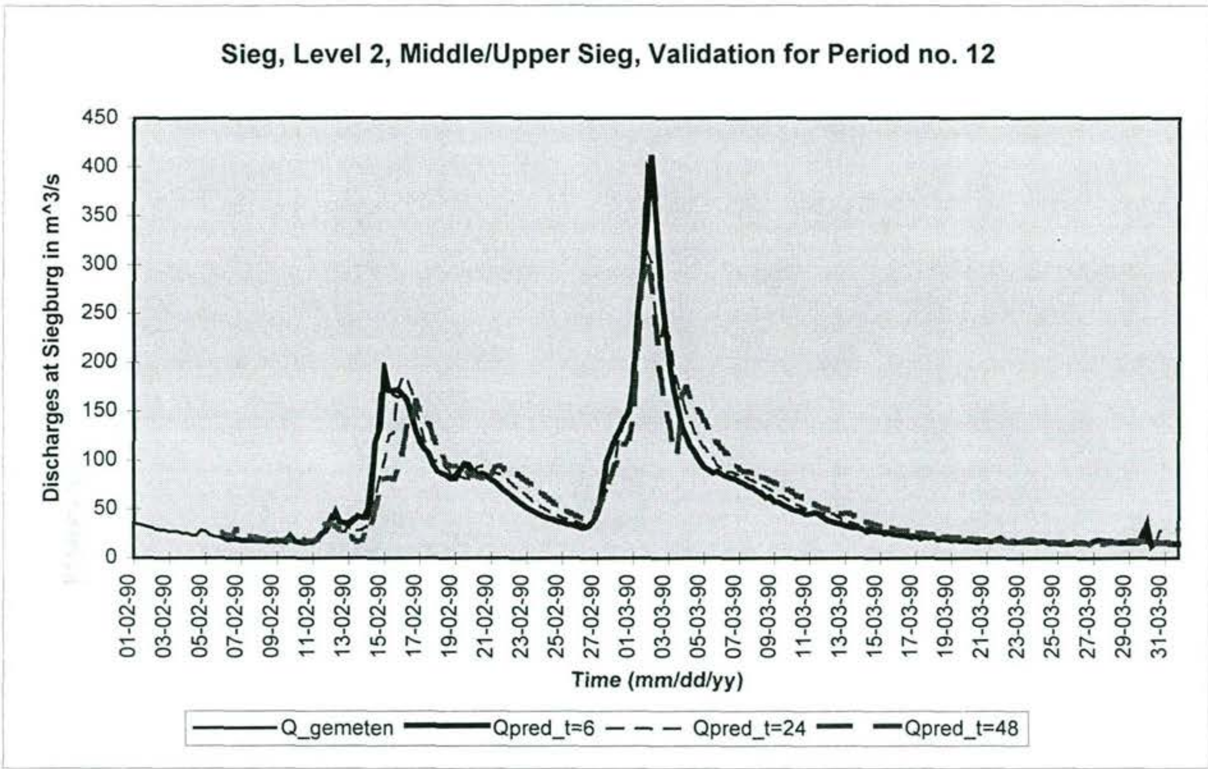


Model parameters			
fmin	0.40	alfa (1,1)	0.52
fmax	5.00	alfa (1,2)	0.41
kb	0.10	alfa (1,3)	0.00
psi	0.94	alfa (1,4)	0.00
kn	8.20	alfa (1,5)	0.00
nn	3.50	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00

Fig. 9.18. Sieg at Siegburg, Sieg Level 2, Middle/Upper Sieg basin, Validation for Period no.12 (fmin=0.40 for Middle/Upper Sieg).

SUMMARY OF VALIDATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	4.3%	33.7%	-86.4%
12	7.2%	44.9%	-87.9%
18	10.8%	46.9%	-69.9%
24	13.7%	50.0%	-75.5%
30	16.7%	55.7%	-85.6%
36	19.4%	60.4%	-92.3%
42	21.8%	61.8%	-94.8%
48	24.1%	63.4%	-97.3%

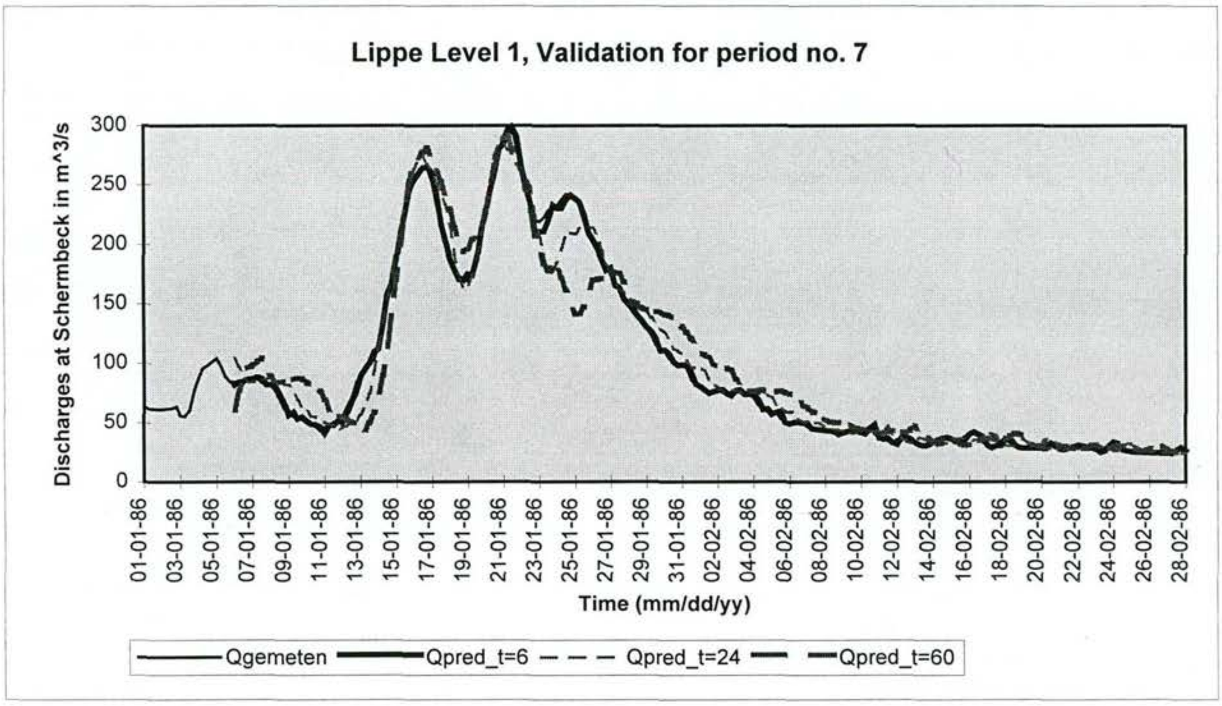


Model parameters			
fmin	0.70	alfa (1,1)	0.52
fmax	5.00	alfa (1,2)	0.41
kb	0.10	alfa (1,3)	0.00
psi	0.94	alfa (1,4)	0.00
kn	8.20	alfa (1,5)	0.00
nn	3.50	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00

Fig. 9.19. Sieg at Siegburg, Sieg Level 2, Middle/Upper Sieg basin, Validation for Period no.12 (fmin=0.70 for Middle/Upper Sieg).

SUMMARY OF VALIDATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	2.8%	11.7%	-19.2%
12	5.7%	21.3%	-27.3%
18	8.3%	32.3%	-33.9%
24	10.1%	39.1%	-38.1%
30	11.4%	44.2%	-47.3%
36	12.7%	46.6%	-48.9%
42	14.2%	47.4%	-54.7%
48	15.7%	49.6%	-62.7%
54	17.4%	51.8%	-66.7%
60	19.4%	53.8%	-76.8%

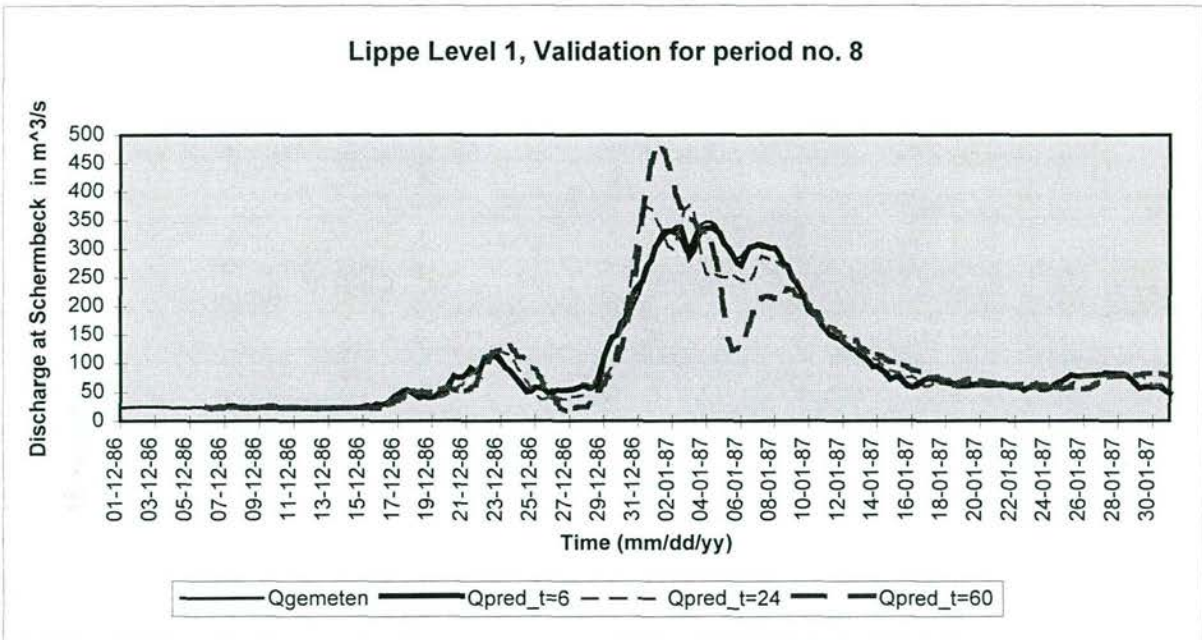


Model parameters			
fmin	0.20	alfa (1,1)	0.52
fmax	5.00	alfa (1,2)	0.41
kb	3.37	alfa (1,3)	0.00
psi	0.80	alfa (1,4)	0.00
kn	32.60	alfa (1,5)	0.00
nn	2.41	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00
		alfa (1,9)	0.00
		alfa (1,10)	0.00

Fig. 9.20. Lippe at Schermbeck, Lippe Level 1, Total Lippe basin, Validation for Period no. 7.

SUMMARY OF VALIDATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	3.0%	23.7%	-12.1%
12	6.2%	32.7%	-29.1%
18	9.6%	35.6%	-44.1%
24	11.7%	35.5%	-51.3%
30	13.7%	36.8%	-55.9%
36	2.5%	6.5%	-1.6%
42	17.0%	52.8%	-75.9%
48	18.4%	59.0%	-77.9%
54	19.9%	64.7%	-81.9%
60	21.1%	70.4%	-87.9%

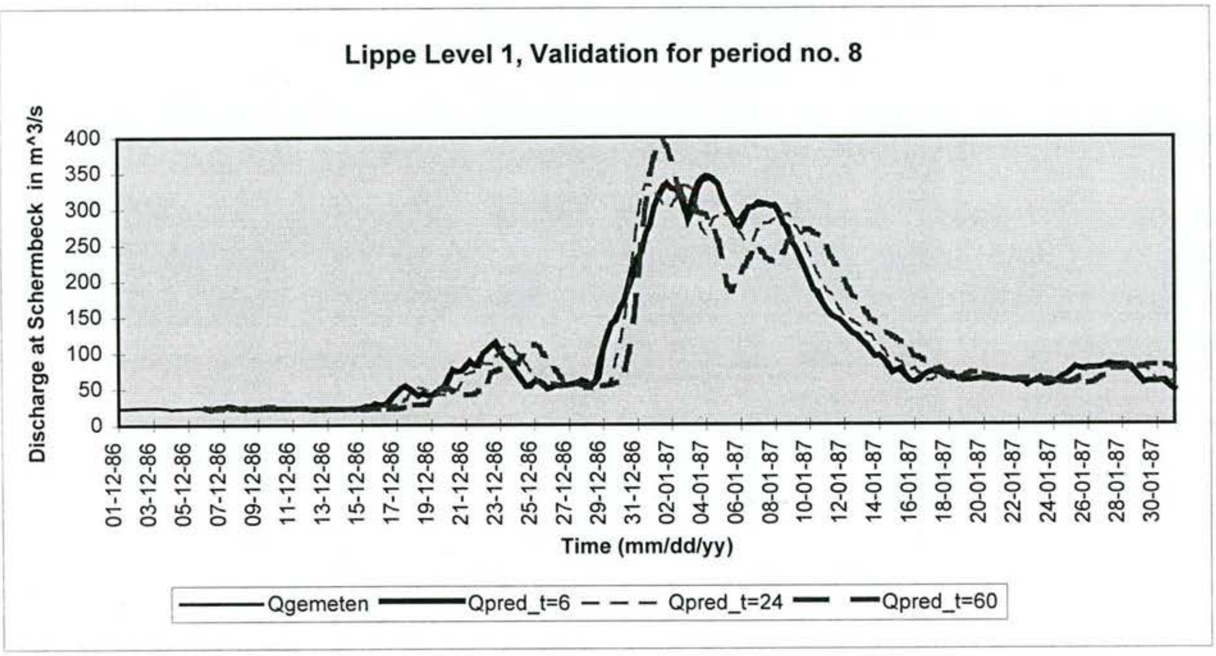


Model parameters			
fmin	0.20	alfa (1,1)	0.52
fmax	5.00	alfa (1,2)	0.41
kb	3.37	alfa (1,3)	0.00
psi	0.80	alfa (1,4)	0.00
kn	32.60	alfa (1,5)	0.00
nn	2.41	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00
		alfa (1,9)	0.00
		alfa (1,10)	0.00

Fig. 9.21. Lippe at Schermbeck, Lippe Level 1, Total Lippe basin, Validation for Period no. 8 (fmin=0.20).

SUMMARY OF VALIDATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	3.0%	27.3%	-10.9%
12	6.6%	41.9%	-24.4%
18	10.2%	52.0%	-45.2%
24	12.5%	56.7%	-59.1%
30	14.8%	59.3%	-69.8%
36	2.5%	6.5%	-1.6%
42	19.0%	62.8%	-95.4%
48	20.7%	62.1%	-103.9%
54	22.5%	60.0%	-95.4%
60	24.3%	61.6%	-87.9%

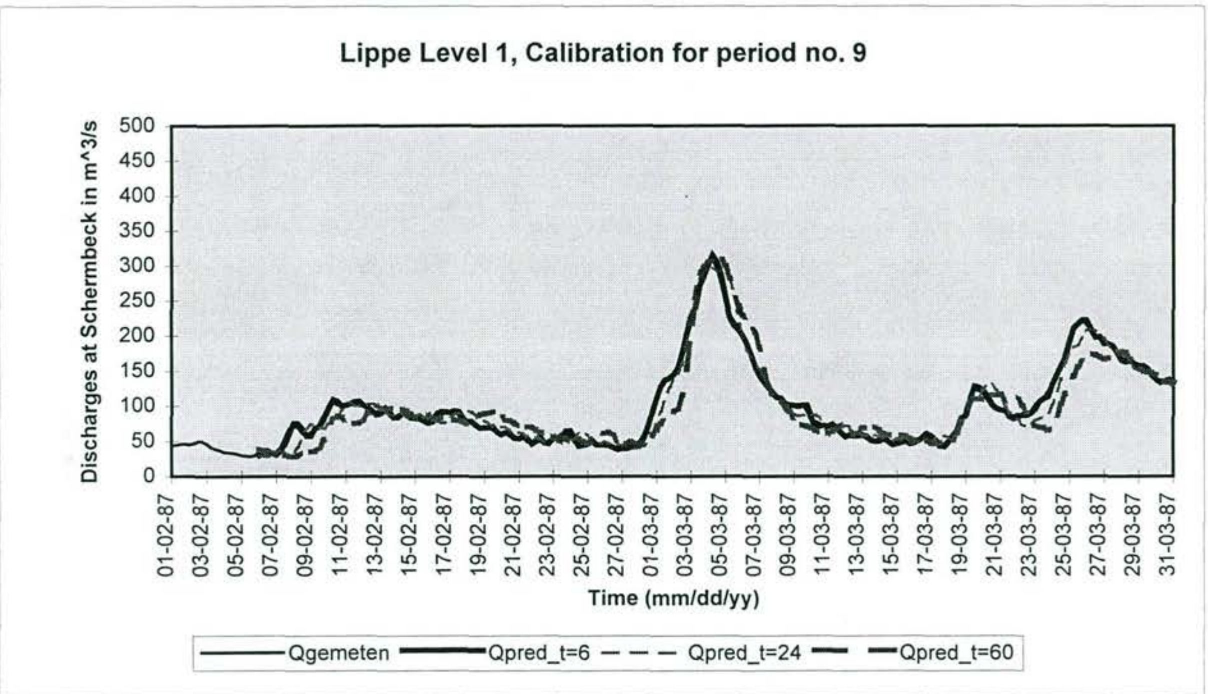


Model parameters			
fmin	0.40	alfa (1,1)	0.52
fmax	5.00	alfa (1,2)	0.41
kb	3.37	alfa (1,3)	0.00
psi	0.80	alfa (1,4)	0.00
kn	32.60	alfa (1,5)	0.00
nn	2.41	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00
		alfa (1,9)	0.00
		alfa (1,10)	0.00

Fig. 9.22. Lippe at Schermbeck, Lippe Level 1, Total Lippe basin, Validation for Period no. 8 (fmin=0.40).

SUMMARY OF CALIBRATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	3.8%	15.2%	-14.1%
12	7.3%	33.9%	-33.3%
18	9.7%	48.7%	-37.7%
24	11.2%	52.9%	-37.7%
30	12.6%	56.0%	-32.3%
36	13.8%	54.3%	-35.4%
42	14.9%	51.1%	-38.8%
48	16.1%	55.7%	-40.1%
54	17.4%	58.6%	-43.8%
60	18.5%	60.7%	-49.6%

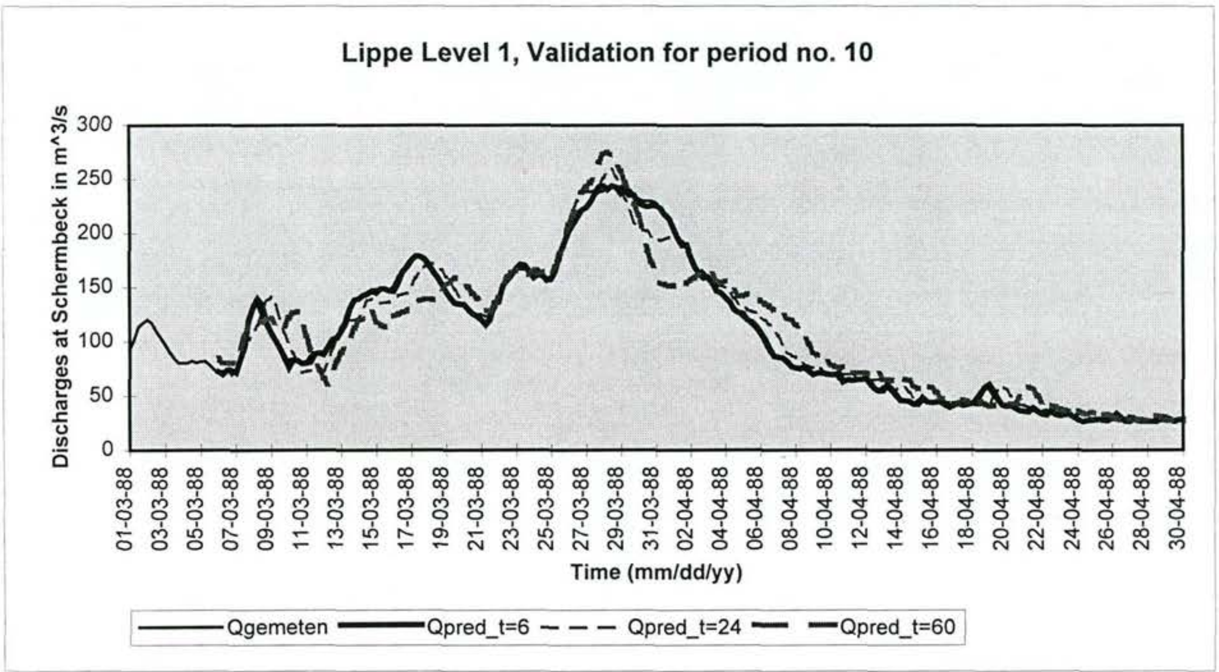


Model parameters			
fmin	0.20	alfa (1,1)	0.52
fmax	5.00	alfa (1,2)	0.41
kb	3.37	alfa (1,3)	0.00
psi	0.80	alfa (1,4)	0.00
kn	32.60	alfa (1,5)	0.00
nn	2.41	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00
		alfa (1,9)	0.00
		alfa (1,10)	0.00

Fig. 9.23. Lippe at Schermbeck, Lippe Level 1, Total Lippe basin, Calibration for Period no. 9

SUMMARY OF VALIDATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	2.4%	11.6%	-9.1%
12	4.9%	21.3%	-23.3%
18	7.1%	26.7%	-33.4%
24	8.8%	27.4%	-39.4%
30	10.5%	28.5%	-46.5%
36	12.1%	29.0%	-59.9%
42	13.6%	28.6%	-64.6%
48	14.9%	31.1%	-60.6%
54	16.1%	34.9%	-64.4%
60	17.2%	35.4%	-55.6%

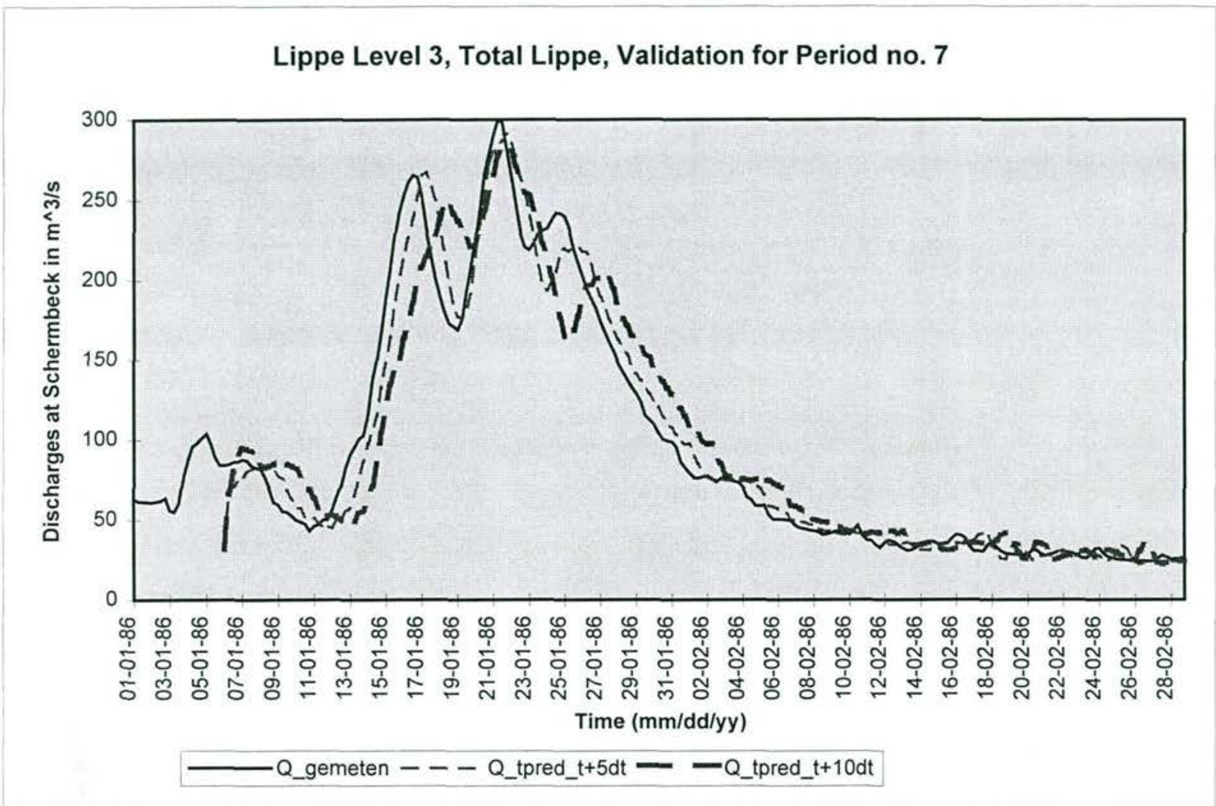


Model parameters			
fmin	0.20	alfa (1,1)	0.52
fmax	5.00	alfa (1,2)	0.41
kb	3.37	alfa (1,3)	0.00
psi	0.80	alfa (1,4)	0.00
kn	32.60	alfa (1,5)	0.00
nn	2.41	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00
		alfa (1,9)	0.00
		alfa (1,10)	0.00

Fig. 9.24. Lippe at Schermbeck, Lippe Level 1, Total Lippe basin, Validation for Period no.10.

SUMMARY OF VALIDATION RESULTS:

Prediction in hours advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum local Efficiency
24	11.8%	60.2%	-37.8%
54	20.6%	62.3%	-62.6%

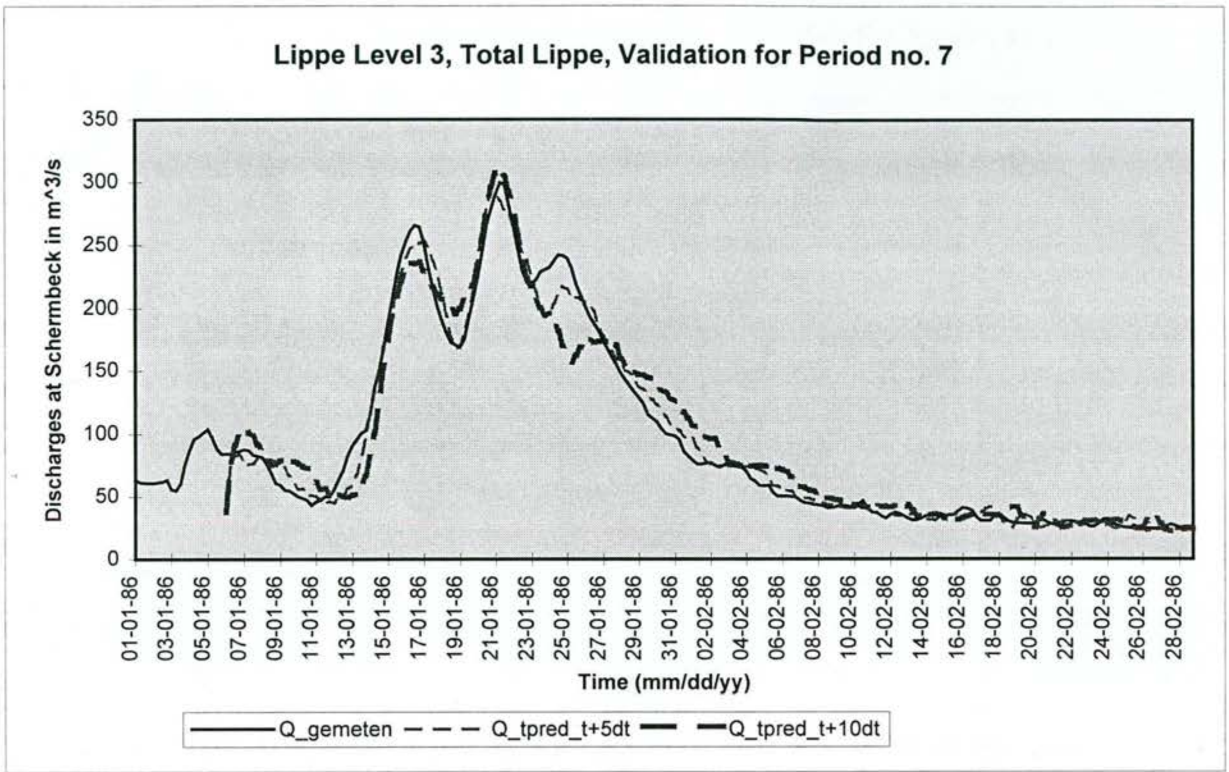


Model parameters	**Lower Lippe**	**Stever**	**Middle Lippe**	**Upper Lippe**
fmin	0.50	0.55	0.35	0.35
fmax	5.00	5.00	5.00	5.00
kb	0.10	0.30	0.10	0.10
psi	1.00	0.90	1.00	0.98
kn	35.00	23.00	35.00	35.00
nn	2.05	2.10	2.20	2.10
alfa (1,1)	0.30	0.20	0.20	0.20
alfa (1,2)	0.10	0.00	0.05	0.10
alfa (1,3)	0.00	0.00	0.00	0.00
alfa (1,4)	0.00	0.00	0.00	0.00
alfa (1,5)	0.00	0.00	0.00	0.00
alfa (1,6)	0.00	0.00	0.00	0.00
alfa (1,7)	0.00	0.00	0.00	0.00
alfa (1.8)	0.00	0.00	0.00	0.00
alfa (1,9)	0.00	0.00	0.00	0.00
alfa (1.10)	0.00	0.00	0.00	0.00

Fig. 9.25. Lippe at Schermbeck, Lippe Level 3, Total Lippe basin, Validation for Period no. 7.

SUMMARY OF VALIDATION RESULTS:

Prediction in hours advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum local Efficiency
24	9.7%	52.9%	-37.8%
54	17.1%	55.1%	-54.2%

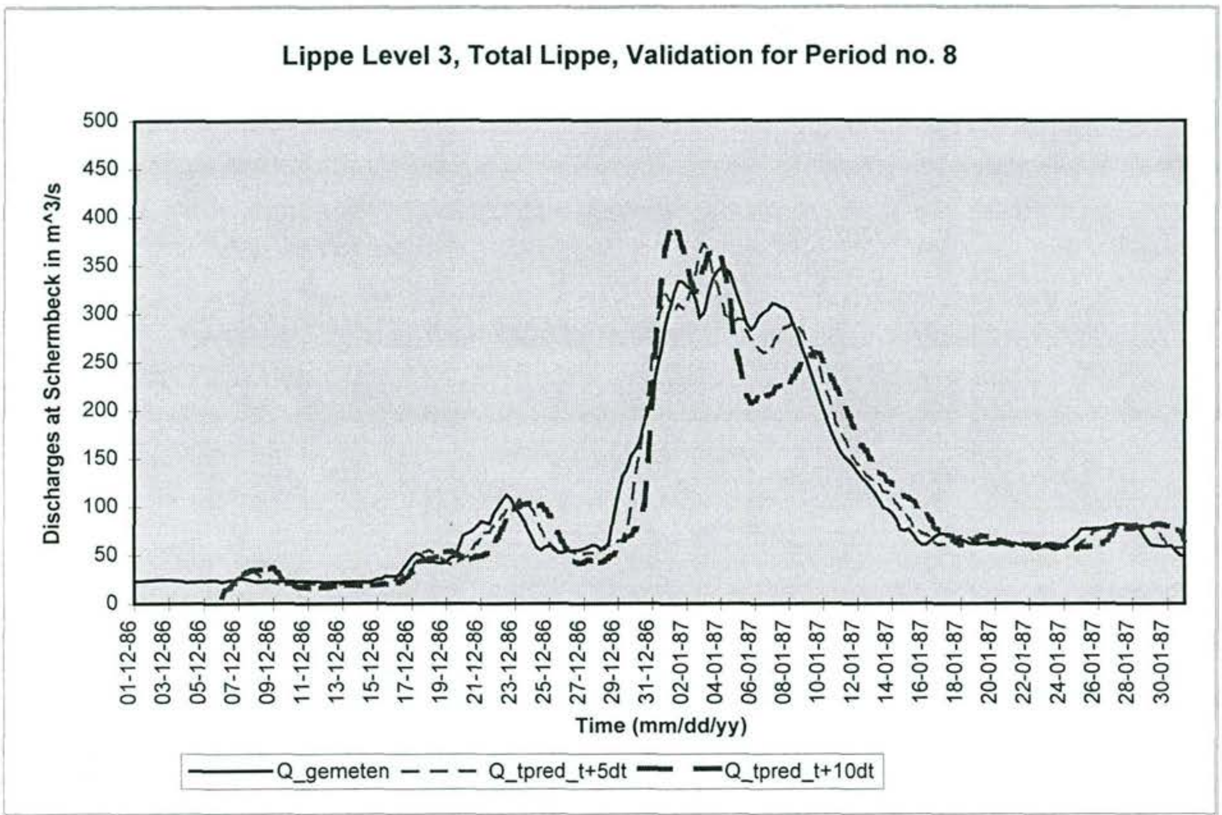


Model parameters	**Lower Lippe**	**Stever**	**Middle Lippe**	**Upper Lippe**
fmin	0.50	0.14	0.25	0.35
fmax	5.00	5.00	5.00	5.00
kb	0.10	0.30	0.10	0.10
psi	1.00	0.90	1.00	0.98
kn	35.00	23.00	35.00	35.00
nn	2.05	2.10	2.20	2.10
alfa (1,1)	0.30	0.20	0.20	0.20
alfa (1,2)	0.10	0.00	0.05	0.10
alfa (1,3)	0.00	0.00	0.00	0.00
alfa (1,4)	0.00	0.00	0.00	0.00
alfa (1,5)	0.00	0.00	0.00	0.00
alfa (1,6)	0.00	0.00	0.00	0.00
alfa (1,7)	0.00	0.00	0.00	0.00
alfa (1.8)	0.00	0.00	0.00	0.00
alfa (1,9)	0.00	0.00	0.00	0.00
alfa (1.10)	0.00	0.00	0.00	0.00

Fig. 9.26. Lippe at Schermbeck, Lippe Level 3, Total Lippe basin, Validation for Period no. 7 (fmin=0.14 for Stever basin and fmin=0.25 for Middle Lippe basin).

SUMMARY OF VALIDATION RESULTS:

Prediction in hours advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum local Efficiency
24	12.3%	65.9%	-51.6%
54	23.4%	67.6%	-83.9%

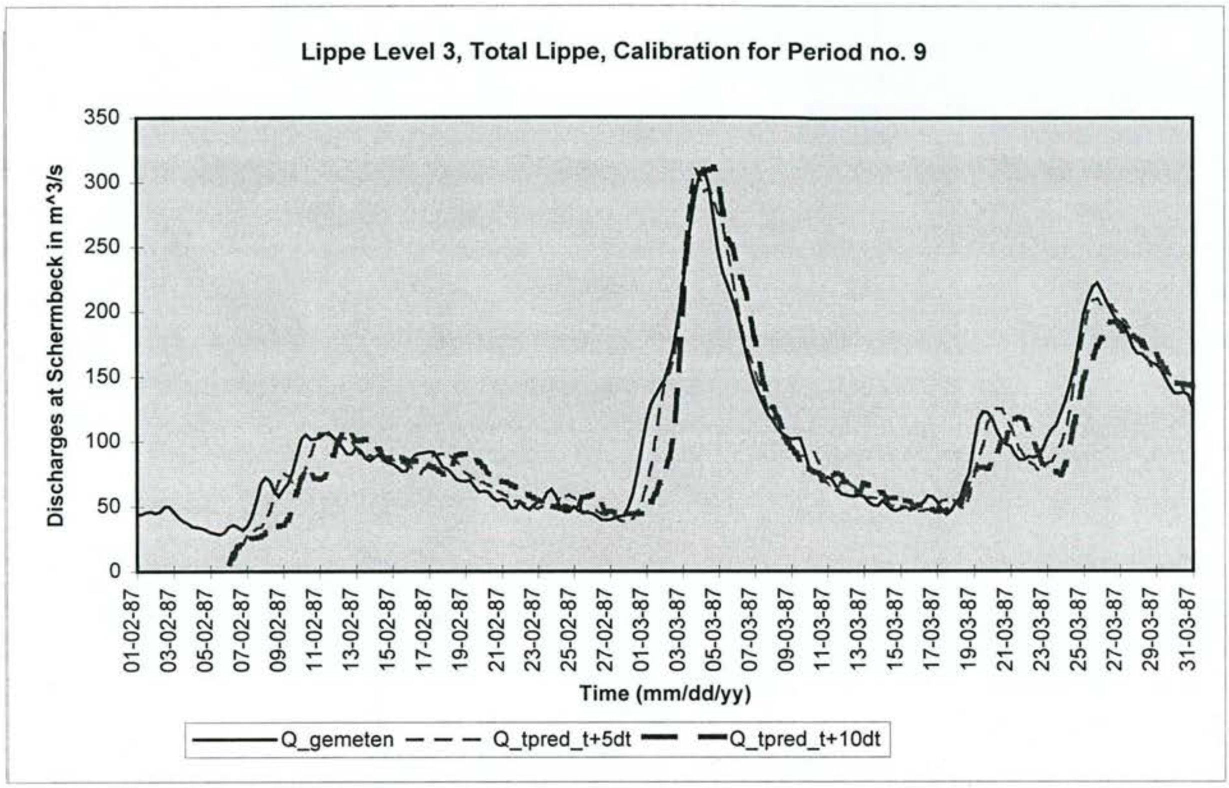


Model Parameters	**Lower Lippe**	**Stever**	**Middle Lippe**	**Upper Lippe**
fmin	0.50	0.55	0.35	0.35
fmax	5.00	5.00	5.00	5.00
kb	0.10	0.30	0.10	0.10
psi	1.00	0.90	1.00	0.98
kn	35.00	23.00	35.00	35.00
nn	2.05	2.10	2.20	2.10
alfa (1,1)	0.30	0.20	0.20	0.20
alfa (1,2)	0.10	0.00	0.05	0.10
alfa (1,3)	0.00	0.00	0.00	0.00
alfa (1,4)	0.00	0.00	0.00	0.00
alfa (1,5)	0.00	0.00	0.00	0.00
alfa (1,6)	0.00	0.00	0.00	0.00
alfa (1,7)	0.00	0.00	0.00	0.00
alfa (1.8)	0.00	0.00	0.00	0.00
alfa (1,9)	0.00	0.00	0.00	0.00
alfa (1.10)	0.00	0.00	0.00	0.00

Fig. 9.27 Lippe at Schermbeck, Lippe Level 3, Total Lippe basin, Validation for Period no. 8.

SUMMARY OF CALIBRATION RESULTS:

Prediction in hours advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum local Efficiency
24	11.5%	84.2%	-29.4%
54	18.8%	80.4%	-37.9%

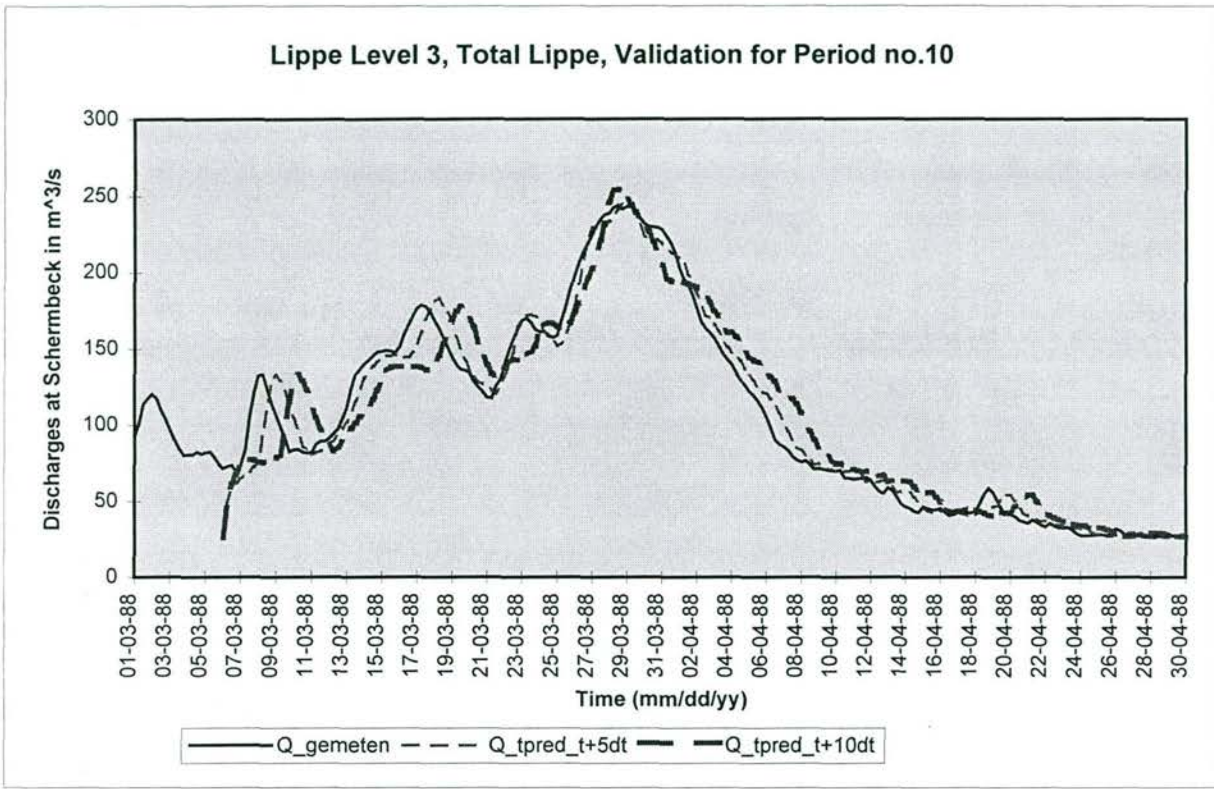


Model Parameters	**Lower Lippe**	**Stever**	**Middle Lippe**	**Upper Lippe**
fmin	0.50	0.55	0.35	0.35
fmax	5.00	5.00	5.00	5.00
kb	0.10	0.30	0.10	0.10
psi	1.00	0.90	1.00	0.98
kn	35.00	23.00	35.00	35.00
nn	2.05	2.10	2.20	2.10
alfa (1,1)	0.30	0.20	0.20	0.20
alfa (1,2)	0.10	0.00	0.05	0.10
alfa (1,3)	0.00	0.00	0.00	0.00
alfa (1,4)	0.00	0.00	0.00	0.00
alfa (1,5)	0.00	0.00	0.00	0.00
alfa (1,6)	0.00	0.00	0.00	0.00
alfa (1,7)	0.00	0.00	0.00	0.00
alfa (1.8)	0.00	0.00	0.00	0.00
alfa (1,9)	0.00	0.00	0.00	0.00
alfa (1.10)	0.00	0.00	0.00	0.00

Fig. 9.28. Lippe at Schermbeck, Lippe Level 3, Total Lippe basin, Calibration for Period no. 9

SUMMARY OF VALIDATION RESULTS:

Prediction in hours advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum local Efficiency
24	8.6%	59.2%	-38.3%
54	16.5%	63.6%	-58.4%

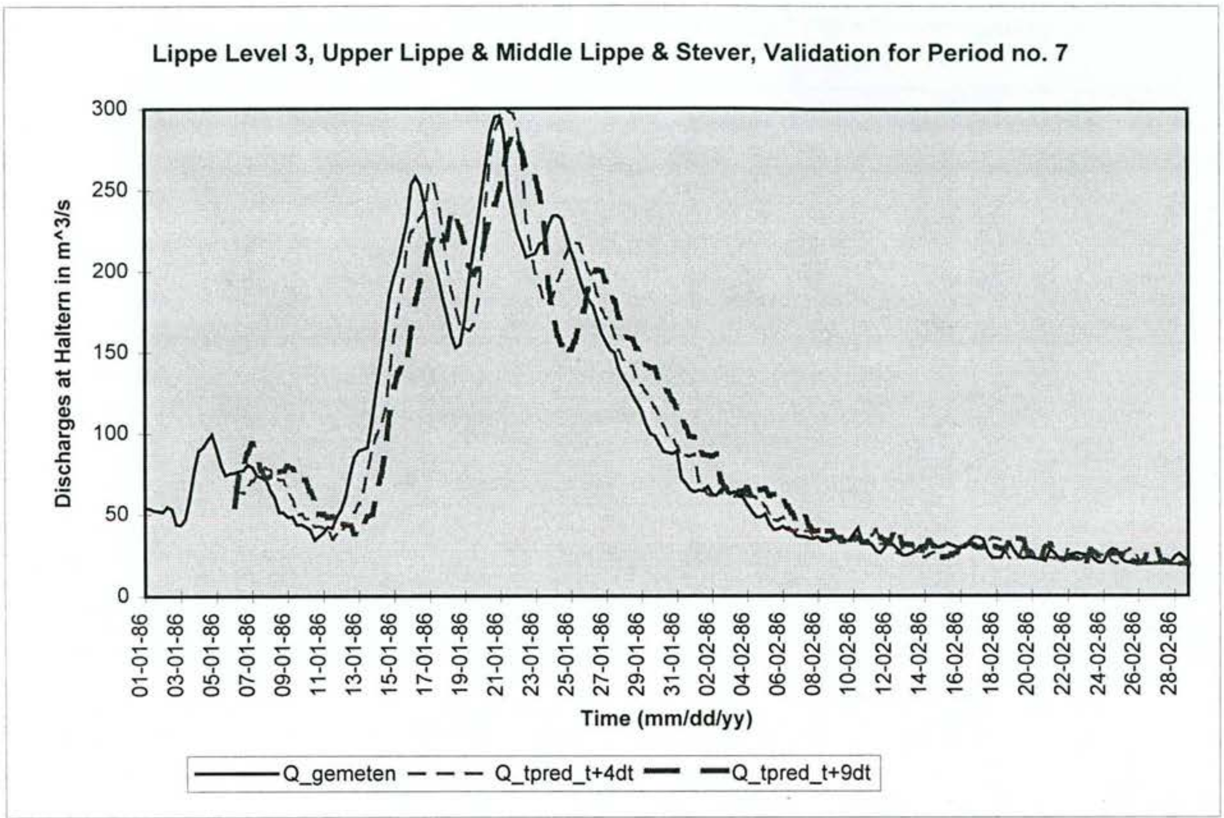


Model Parameters	**Lower Lippe**	**Stever**	**Middle Lippe**	**Upper Lippe**
fmin	0.50	0.55	0.35	0.35
fmax	5.00	5.00	5.00	5.00
kb	0.10	0.30	0.10	0.10
psi	1.00	0.90	1.00	0.98
kn	35.00	23.00	35.00	35.00
nn	2.05	2.10	2.20	2.10
alfa (1,1)	0.30	0.20	0.20	0.20
alfa (1,2)	0.10	0.00	0.05	0.10
alfa (1,3)	0.00	0.00	0.00	0.00
alfa (1,4)	0.00	0.00	0.00	0.00
alfa (1,5)	0.00	0.00	0.00	0.00
alfa (1,6)	0.00	0.00	0.00	0.00
alfa (1,7)	0.00	0.00	0.00	0.00
alfa (1.8)	0.00	0.00	0.00	0.00
alfa (1,9)	0.00	0.00	0.00	0.00
alfa (1.10)	0.00	0.00	0.00	0.00

Fig. 9.29. Lippe at Schermbeck, Lippe Level 3, Total Lippe basin, Validation for Period no. 10.

SUMMARY OF VALIDATION RESULTS:

Prediction in hours advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum local Efficiency
24	14.2%	42.2%	-52.9%
54	23.2%	55.0%	-74.1%

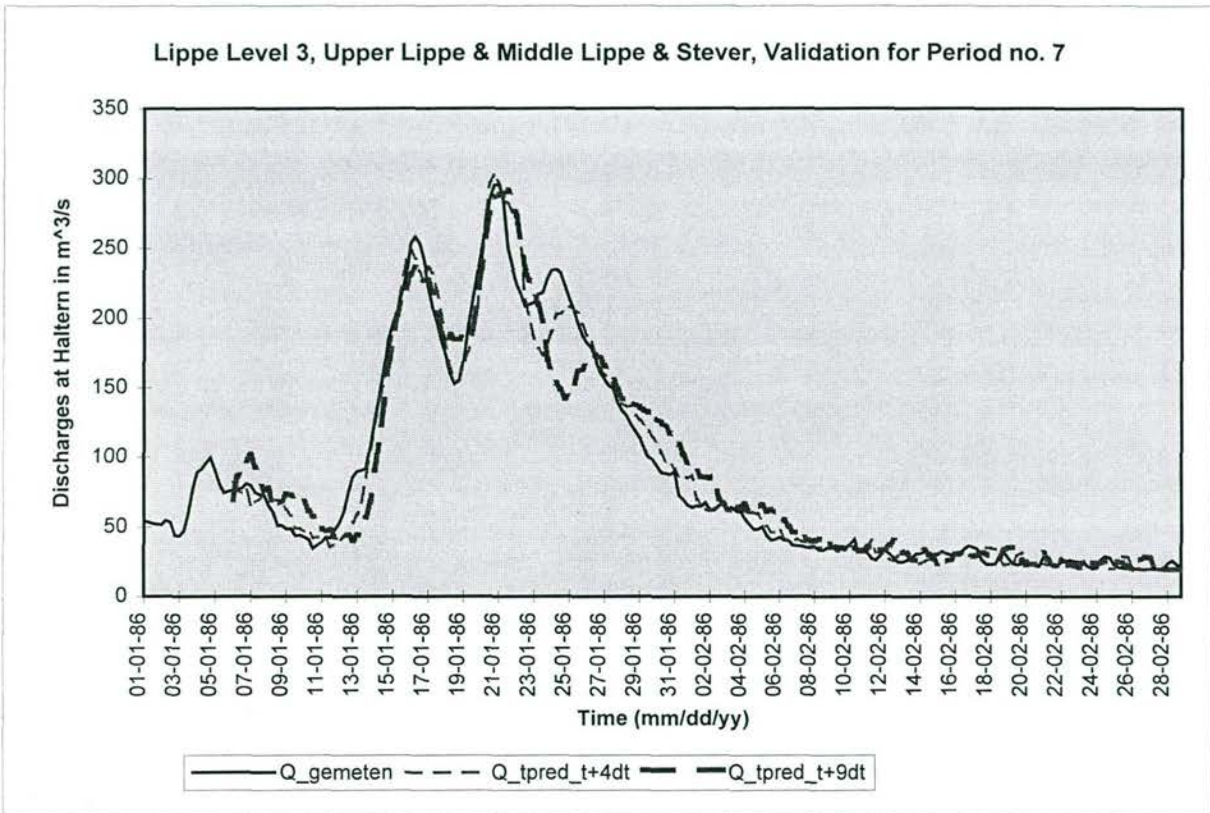


Model Parameters	Stever	Middle Lippe	Upper Lippe
fmin	0.55	0.35	0.35
fmax	5.00	5.00	5.00
kb	0.30	0.10	0.10
psi	0.90	1.00	0.98
kn	23.00	35.00	35.00
nn	2.10	2.20	2.10
alfa (1,1)	0.20	0.20	0.20
alfa (1,2)	0.00	0.05	0.10
alfa (1,3)	0.00	0.00	0.00
alfa (1,4)	0.00	0.00	0.00
alfa (1,5)	0.00	0.00	0.00
alfa (1,6)	0.00	0.00	0.00
alfa (1,7)	0.00	0.00	0.00
alfa (1.8)	0.00	0.00	0.00
alfa (1,9)	0.00	0.00	0.00

Fig. 9.30. Lippe at Haltern, Lippe Level 3, Upper Lippe & Middle Lippe and Stever basins, Validation for Period no. 7.

SUMMARY OF VALIDATION RESULTS:

Prediction in hours advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum local Efficiency
24	11.8%	40.8%	-52.9%
54	19.0%	52.9%	-66.8%

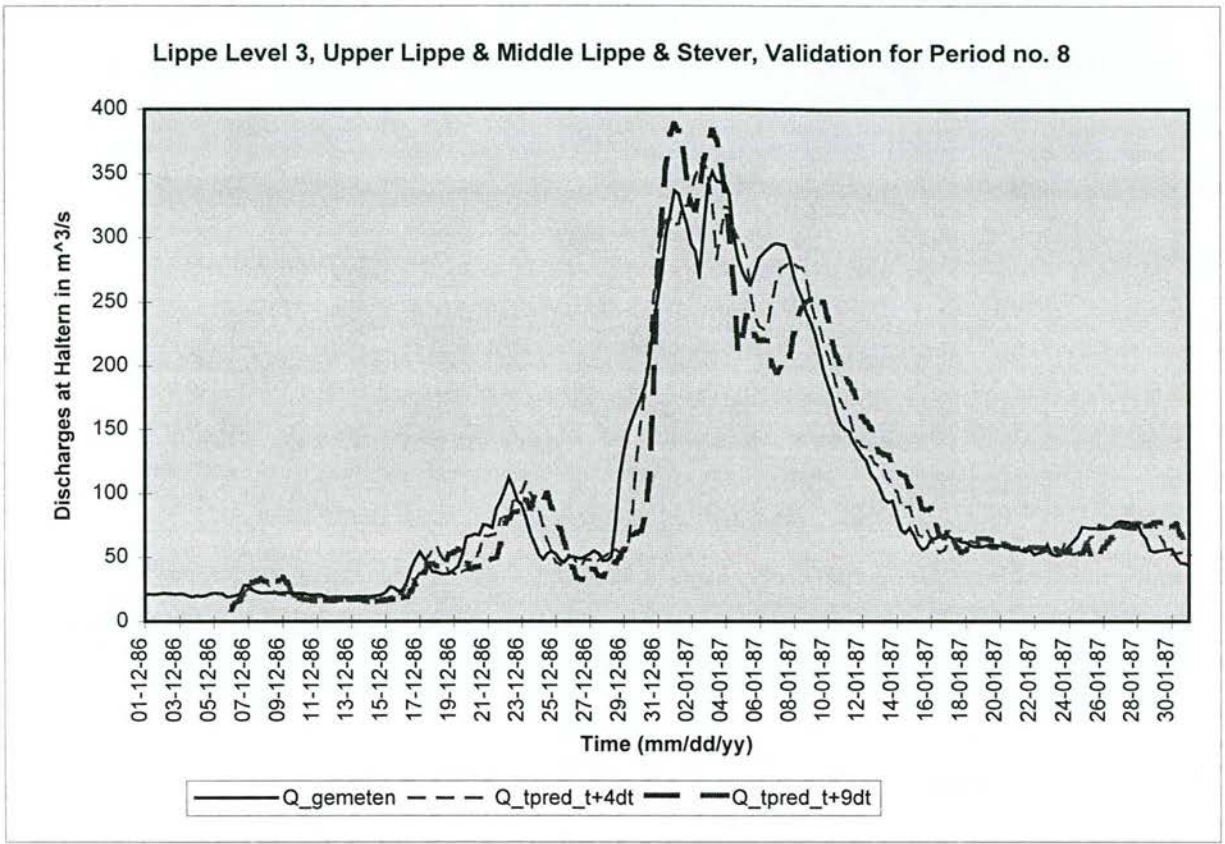


Model Parameters	**Stever**	**Middle Lippe**	**Upper Lippe**
fmin	0.14	0.25	0.35
fmax	5.00	5.00	5.00
kb	0.30	0.10	0.10
psi	0.90	1.00	0.98
kn	23.00	35.00	35.00
nn	2.10	2.20	2.10
alfa (1,1)	0.20	0.20	0.20
alfa (1,2)	0.00	0.05	0.10
alfa (1,3)	0.00	0.00	0.00
alfa (1,4)	0.00	0.00	0.00
alfa (1,5)	0.00	0.00	0.00
alfa (1,6)	0.00	0.00	0.00
alfa (1,7)	0.00	0.00	0.00
alfa (1.8)	0.00	0.00	0.00
alfa (1,9)	0.00	0.00	0.00

Fig. 9.31. Lippe at Haltern, Lippe Level 3, Upper Lippe & Middle Lippe and Stever basins, Validation for Period no. 7 (fmin=0.14 for Stever basin and fmin=0.25 for Middle Lippe basin)

SUMMARY OF VALIDATION RESULTS:

Prediction in hours advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum local Efficiency
24	13.6%	59.2%	-65.4%
54	24.4%	59.1%	-97.3%

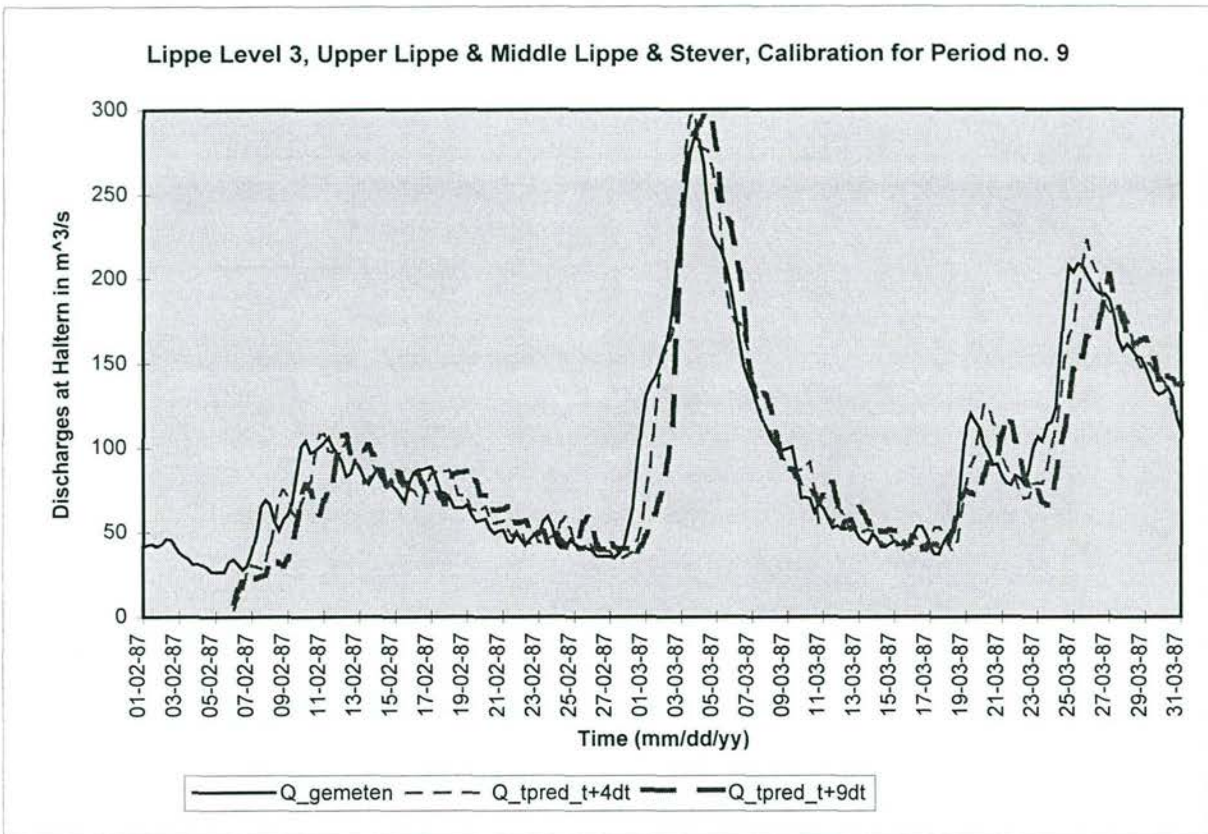


Model Parameters	**Stever**	**Middle Lippe**	**Upper Lippe**
fmin	0.55	0.35	0.35
fmax	5.00	5.00	5.00
kb	0.30	0.10	0.10
psi	0.90	1.00	0.98
kn	23.00	35.00	35.00
nn	2.10	2.20	2.10
alfa (1,1)	0.20	0.20	0.20
alfa (1,2)	0.00	0.05	0.10
alfa (1,3)	0.00	0.00	0.00
alfa (1,4)	0.00	0.00	0.00
alfa (1,5)	0.00	0.00	0.00
alfa (1,6)	0.00	0.00	0.00
alfa (1,7)	0.00	0.00	0.00
alfa (1.8)	0.00	0.00	0.00
alfa (1,9)	0.00	0.00	0.00

Fig. 9.32. Lippe at Haltern, Lippe Level 3, Upper Lippe & Middle Lippe & Stever basins, Validation for Period no. 8.

SUMMARY OF CALIBRATION RESULTS:

Prediction in hours advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum local Efficiency
24	13.6%	87.4%	-44.5%
54	21.0%	75.2%	-50.8%

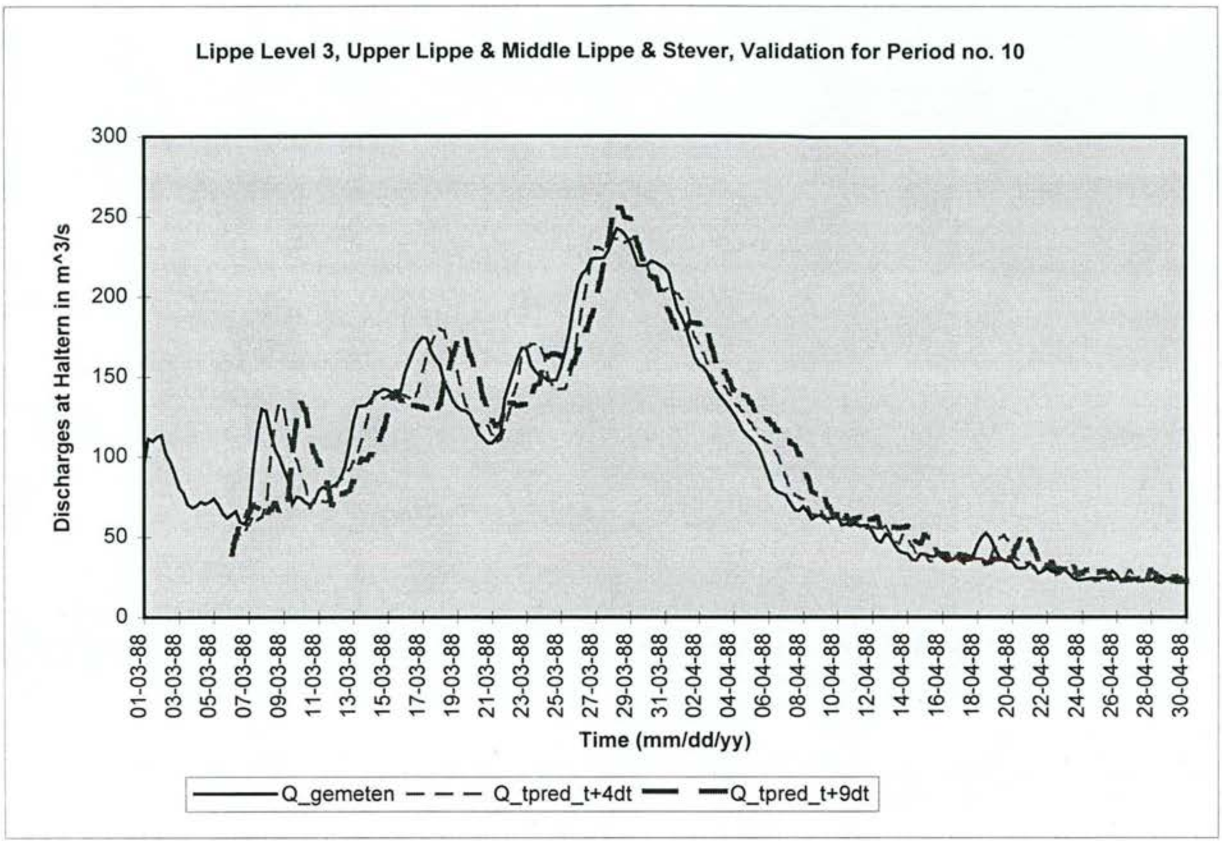


Model Parameters	**Stever**	**Middle Lippe**	**Upper Lippe**
fmin	0.55	0.35	0.35
fmax	5.00	5.00	5.00
kb	0.30	0.10	0.10
psi	0.90	1.00	0.98
kn	23.00	35.00	35.00
nn	2.10	2.20	2.10
alfa (1,1)	0.20	0.20	0.20
alfa (1,2)	0.00	0.05	0.10
alfa (1,3)	0.00	0.00	0.00
alfa (1,4)	0.00	0.00	0.00
alfa (1,5)	0.00	0.00	0.00
alfa (1,6)	0.00	0.00	0.00
alfa (1,7)	0.00	0.00	0.00
alfa (1.8)	0.00	0.00	0.00
alfa (1,9)	0.00	0.00	0.00

Fig. 9.33. Lippe at Haltern, Lippe Level 3, Upper Lippe & Middle Lippe & Stever basins, Calibration for Period no. 9.

SUMMARY OF VALIDATION RESULTS:

Prediction in hours advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum local Efficiency
24	10.2%	51.5%	-46.6%
54	18.7%	50.5%	-80.7%

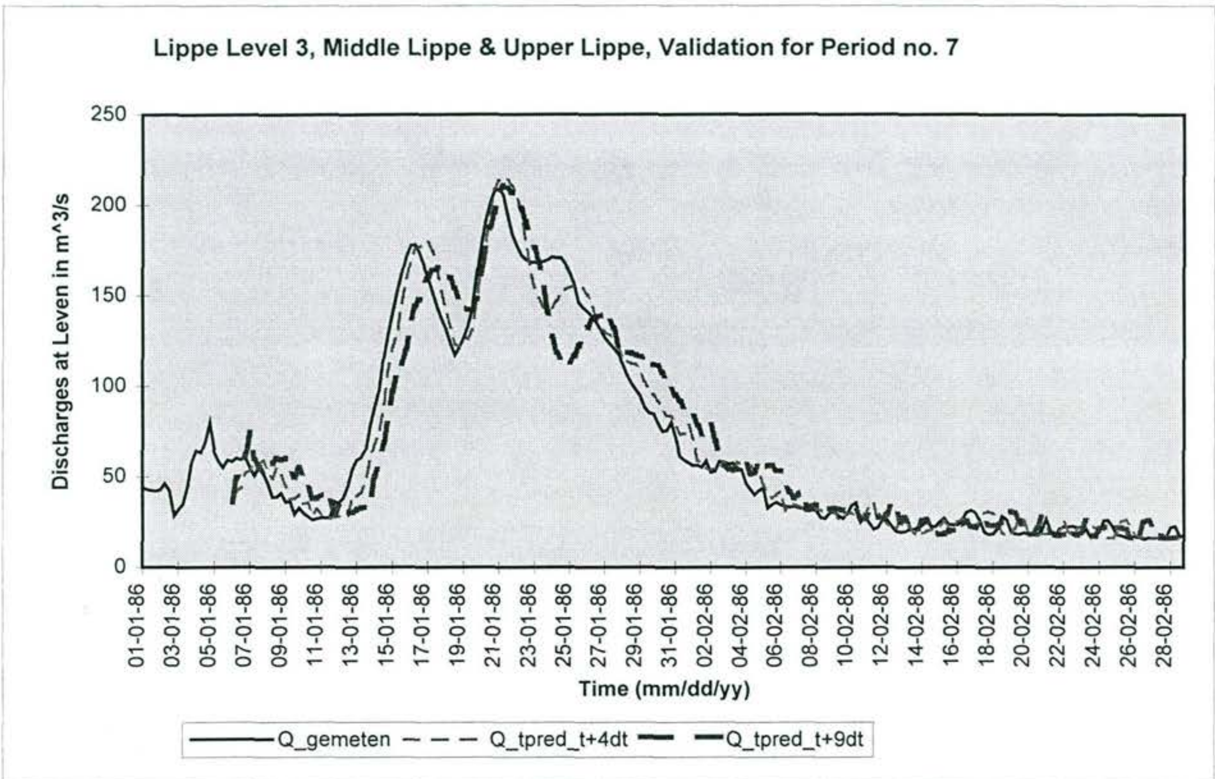


Model Parameters	**Stever**	**Middle Lippe**	**Upper Lippe**
fmin	0.55	0.35	0.35
fmax	5.00	5.00	5.00
kb	0.30	0.10	0.10
psi	0.90	1.00	0.98
kn	23.00	35.00	35.00
nn	2.10	2.20	2.10
alfa (1,1)	0.20	0.20	0.20
alfa (1,2)	0.00	0.05	0.10
alfa (1,3)	0.00	0.00	0.00
alfa (1,4)	0.00	0.00	0.00
alfa (1,5)	0.00	0.00	0.00
alfa (1,6)	0.00	0.00	0.00
alfa (1,7)	0.00	0.00	0.00
alfa (1.8)	0.00	0.00	0.00
alfa (1,9)	0.00	0.00	0.00

Fig. 9.34. Lippe at Haltern, Lippe Level 3, Upper Lippe & Middle Lippe & Stever basins, Validation for Period no. 10.

SUMMARY OF VALIDATION RESULTS:

Prediction in hours advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum local Efficiency
24	14.1%	69.3%	-36.9%
54	22.5%	75.0%	-54.4%

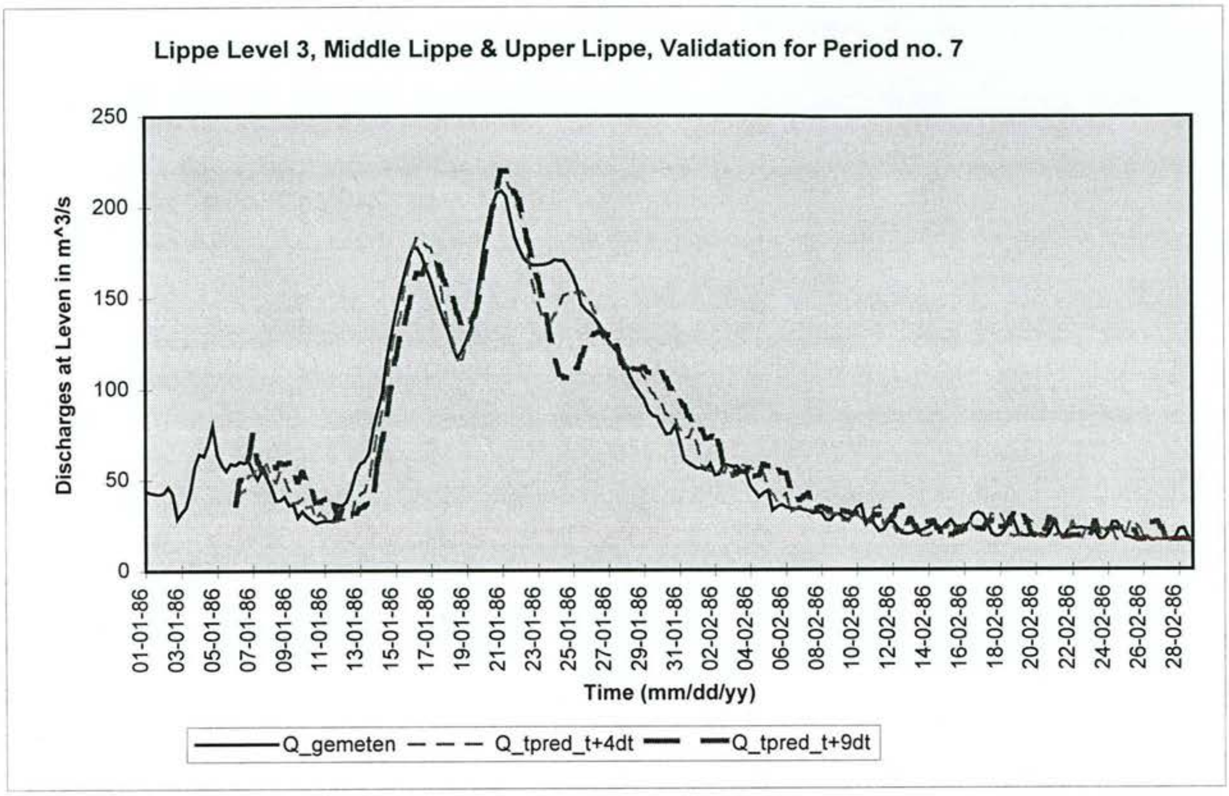


Model parameters	**Middle Lippe**	**Upper Lippe**
fmin	0.35	0.35
fmax	5.00	5.00
kb	0.10	0.10
psi	1.00	0.98
kn	35.00	35.00
nn	2.20	2.10
alfa (1,1)	0.20	0.20
alfa (1,2)	0.05	0.10
alfa (1,3)	0.00	0.00
alfa (1,4)	0.00	0.00
alfa (1,5)	0.00	0.00
alfa (1,6)	0.00	0.00
alfa (1,7)	0.00	0.00
alfa (1.8)	0.00	0.00
alfa (1,9)	0.00	0.00
alfa (1.10)	0.00	0.00

Fig. 9.35. Lippe at Leven, Lippe Level 3, Middle Lippe & Upper Lippe basins, Validation for Period no. 7.

SUMMARY OF VALIDATION RESULTS:

Prediction in hours advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum local Efficiency
24	13.3%	69.3%	-36.9%
54	21.2%	75.0%	-44.6%

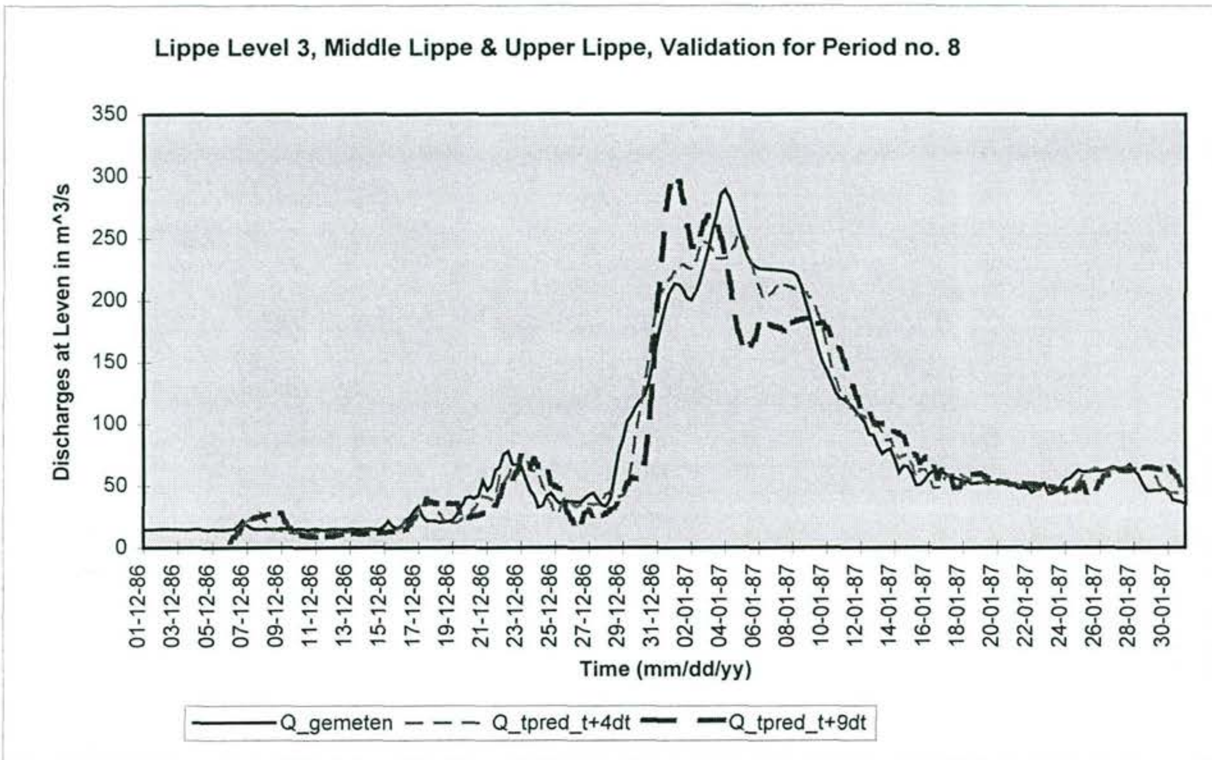


Model parameters	Middle Lippe	Upper Lippe
fmin	0.25	0.35
fmax	5.00	5.00
kb	0.10	0.10
psi	1.00	0.98
kn	35.00	35.00
nn	2.20	2.10
alfa (1,1)	0.20	0.20
alfa (1,2)	0.05	0.10
alfa (1,3)	0.00	0.00
alfa (1,4)	0.00	0.00
alfa (1,5)	0.00	0.00
alfa (1,6)	0.00	0.00
alfa (1,7)	0.00	0.00
alfa (1.8)	0.00	0.00
alfa (1,9)	0.00	0.00
alfa (1.10)	0.00	0.00

Fig. 9.36. Lippe at Leven, Lippe Level 3, Middle Lippe & Upper Lippe basins, Validation for Period no. 7 (fmin=0.25 for Middle Lippe basin).

SUMMARY OF VALIDATION RESULTS:

Prediction in hours advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum local Efficiency
24	15.1%	91.0%	-65.4%
54	28.3%	103.7%	-65.4%

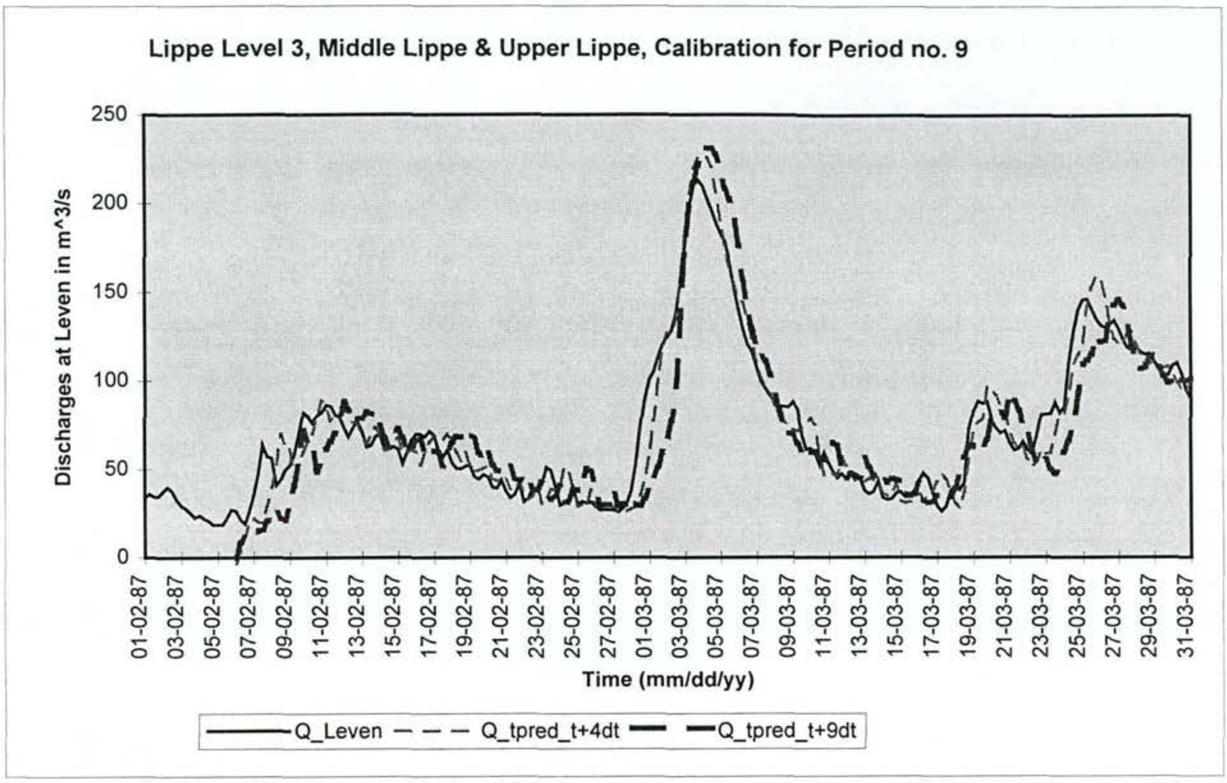


Model parameters	**Middle Lippe**	**Upper Lippe**
fmin	0.35	0.35
fmax	5.00	5.00
kb	0.10	0.10
psi	1.00	0.98
kn	35.00	35.00
nn	2.20	2.10
alfa (1,1)	0.20	0.20
alfa (1,2)	0.05	0.10
alfa (1,3)	0.00	0.00
alfa (1,4)	0.00	0.00
alfa (1,5)	0.00	0.00
alfa (1,6)	0.00	0.00
alfa (1,7)	0.00	0.00
alfa (1.8)	0.00	0.00
alfa (1,9)	0.00	0.00
alfa (1.10)	0.00	0.00

Fig. 9.37 Lippe at Leven, Lippe Level 3, Middle Lippe & Upper Lippe basins, Validation for Period no. 8.

SUMMARY OF CALIBRATION RESULTS:

Prediction in hours advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum local Efficiency
24	14.6%	80.4%	-113.1%
54	21.8%	63.3%	-100.6%

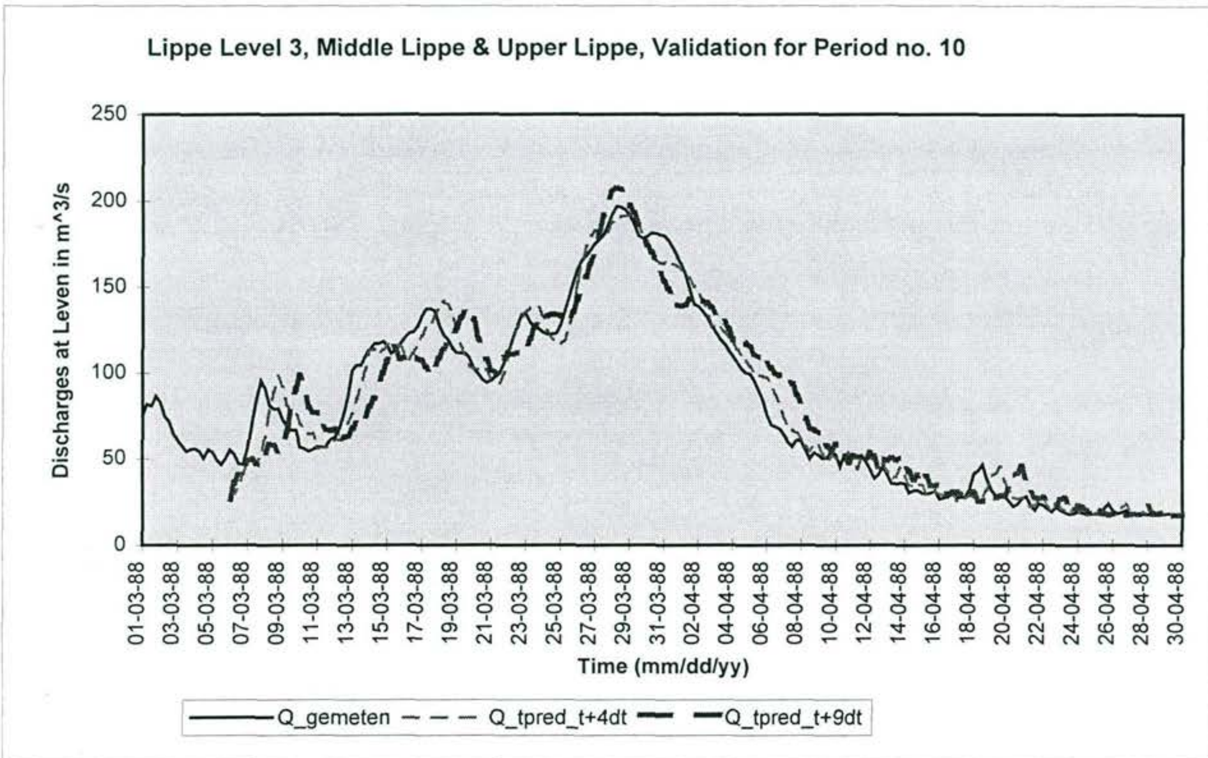


Model parameters	Middle Lippe	Upper Lippe
fmin	0.35	0.35
fmax	5.00	5.00
kb	0.10	0.10
psi	1.00	0.98
kn	35.00	35.00
nn	2.20	2.10
alfa (1,1)	0.20	0.20
alfa (1,2)	0.05	0.10
alfa (1,3)	0.00	0.00
alfa (1,4)	0.00	0.00
alfa (1,5)	0.00	0.00
alfa (1,6)	0.00	0.00
alfa (1,7)	0.00	0.00
alfa (1.8)	0.00	0.00
alfa (1,9)	0.00	0.00
alfa (1.10)	0.00	0.00

Fig. 9.38 Lippe at Leven, Lippe Level 3, Middle Lippe & Upper Lippe basins, Calibration for Period no. 9.

SUMMARY OF VALIDATION RESULTS:

Prediction in hours advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum local Efficiency
24	9.8%	63.2%	-52.9%
54	18.4%	78.5%	-51.5%

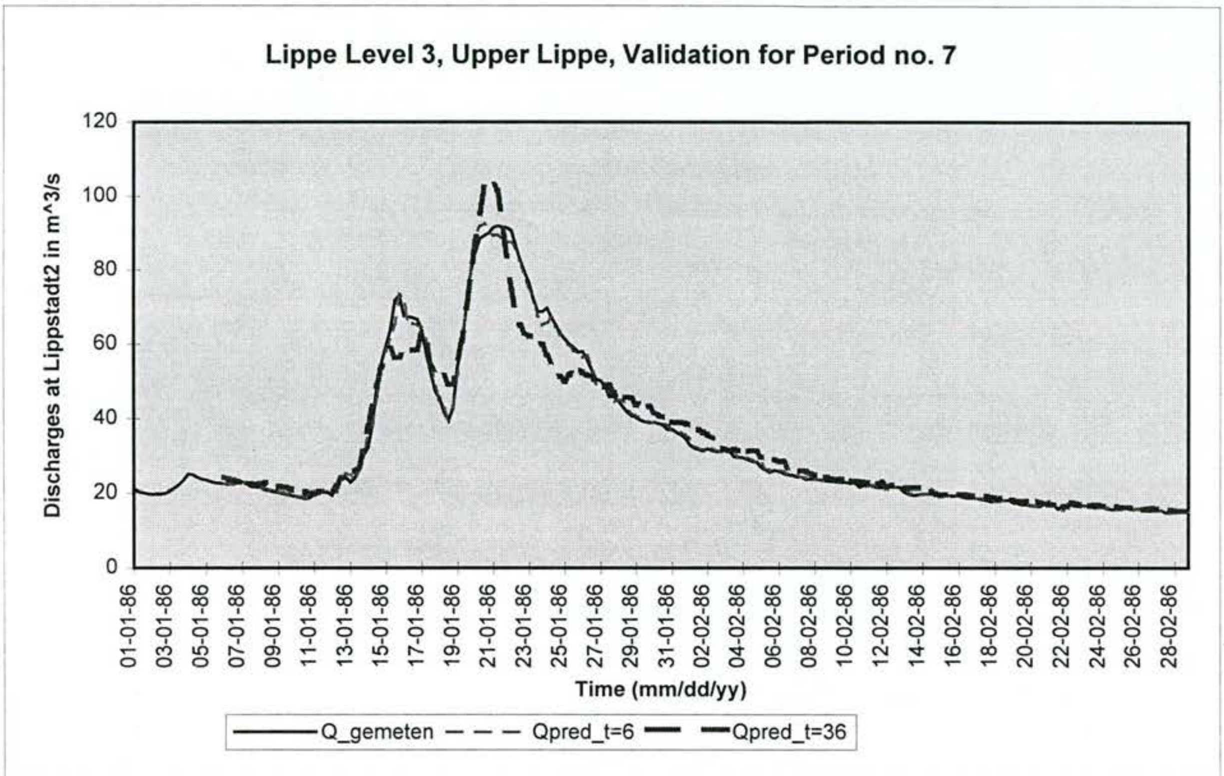


Model parameters	**Middle Lippe**	**Upper Lippe**
fmin	0.35	0.35
fmax	5.00	5.00
kb	0.10	0.10
psi	1.00	0.98
kn	35.00	35.00
nn	2.20	2.10
alfa (1,1)	0.20	0.20
alfa (1,2)	0.05	0.10
alfa (1,3)	0.00	0.00
alfa (1,4)	0.00	0.00
alfa (1,5)	0.00	0.00
alfa (1,6)	0.00	0.00
alfa (1,7)	0.00	0.00
alfa (1.8)	0.00	0.00
alfa (1,9)	0.00	0.00
alfa (1.10)	0.00	0.00

Fig. 9.39. Lippe at Leven, Lippe Level 3, Middle Lippe & Upper Lippe basins, Validation for Period no. 10.

SUMMARY OF VALIDATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	1.8%	9.2%	-10.4%
12	3.1%	13.3%	-13.1%
18	4.1%	15.7%	-18.6%
24	4.9%	17.9%	-19.0%
30	5.9%	21.7%	-22.6%
36	6.9%	22.7%	-24.5%

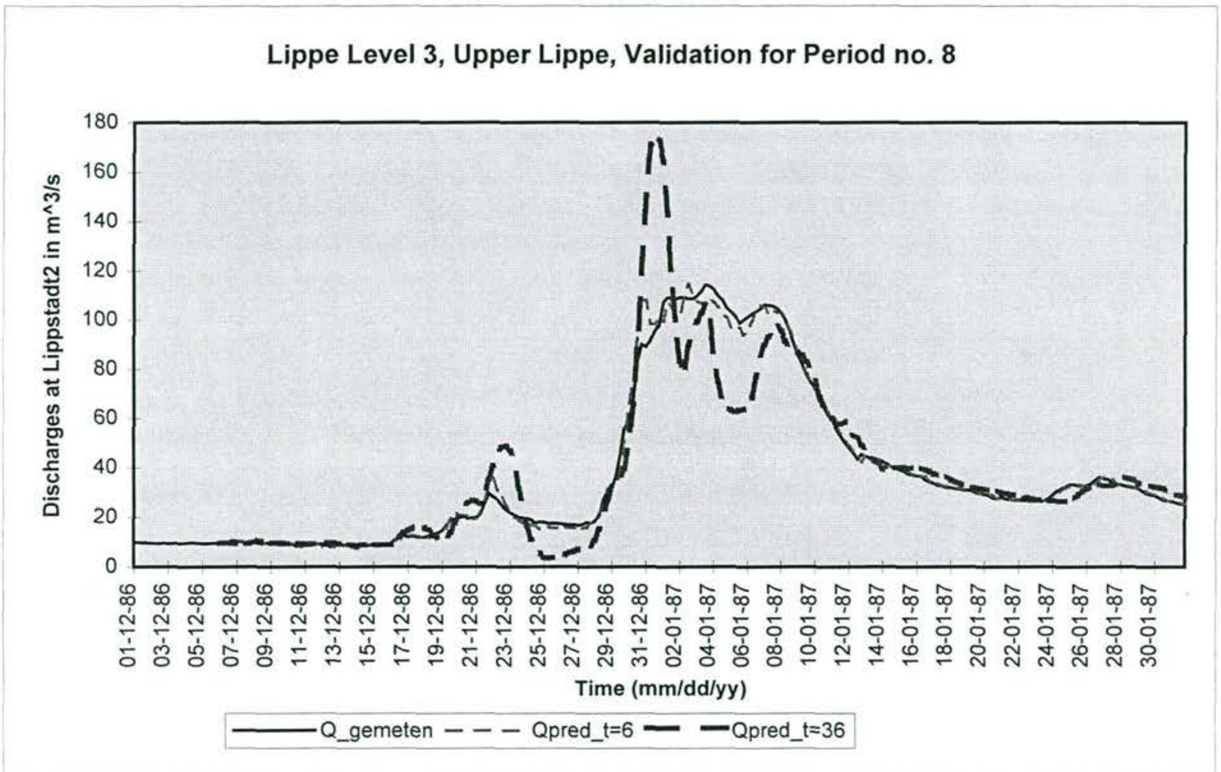


Model parameters			
fmin	0.35	alfa (1,1)	0.20
fmax	5.00	alfa (1,2)	0.10
kb	0.10	alfa (1,3)	0.00
psi	0.98	alfa (1,4)	0.00
kn	35.00	alfa (1,5)	0.00
nn	2.10	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00
		alfa (1,9)	0.00
		alfa (1.10)	0.00

Fig. 9.40. Lippe at Lippstad2, Lippe Level 3, Upper Lippe basin, Validation for Period no. 7.

SUMMARY OF VALIDATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	3.8%	16.3%	-27.4%
12	7.6%	30.3%	-49.6%
18	10.8%	43.1%	-74.4%
24	13.6%	55.9%	-89.9%
30	16.2%	67.9%	-104.9%
36	18.7%	79.5%	-114.6%

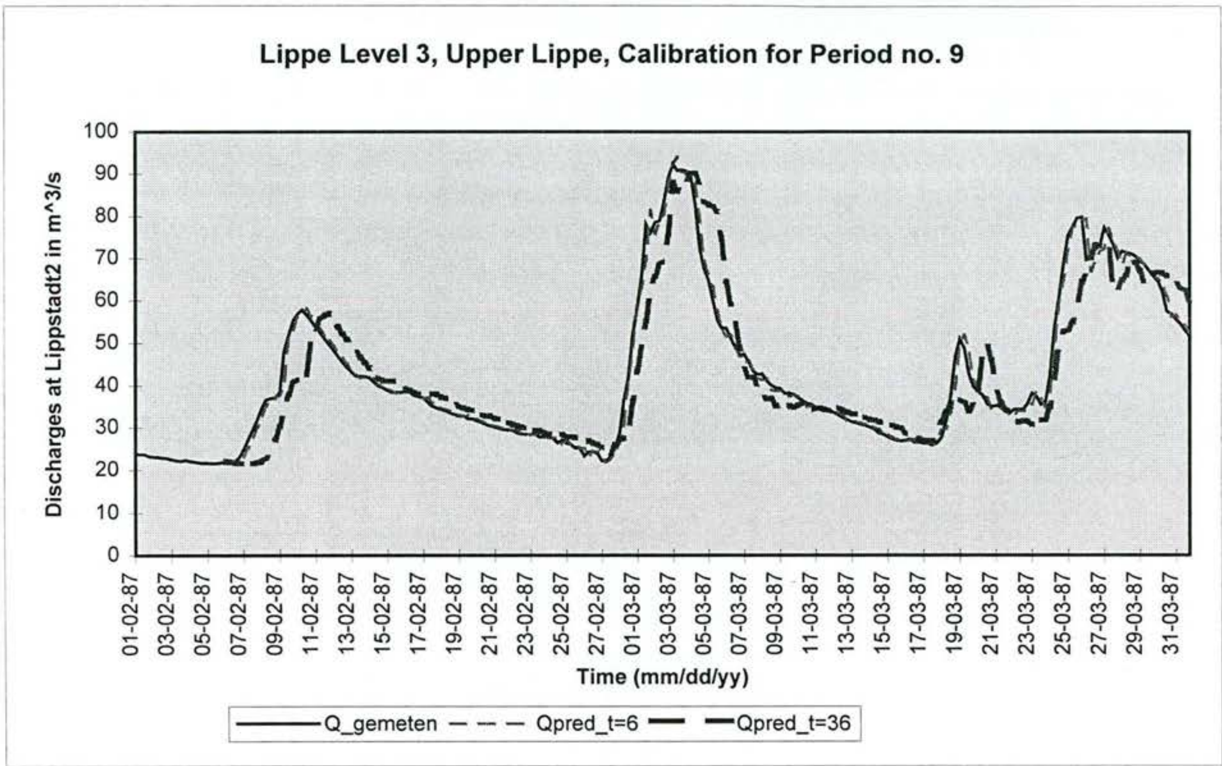


Model parameters			
fmin	0.35	alfa (1,1)	0.20
fmax	5.00	alfa (1,2)	0.10
kb	0.10	alfa (1,3)	0.00
psi	0.98	alfa (1,4)	0.00
kn	35.00	alfa (1,5)	0.00
nn	2.10	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00
		alfa (1,9)	0.00
		alfa (1.10)	0.00

Fig. 9.41. Lippe at Lippstadt2, Lippe Level 3, Upper Lippe basin, Validation for Period no. 8.

SUMMARY OF CALIBRATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	2.5%	17.0%	-14.0%
12	4.8%	25.9%	-21.2%
18	6.7%	30.7%	-28.3%
24	8.3%	33.9%	-30.9%
30	9.8%	33.4%	-38.3%
36	11.2%	37.1%	-46.8%

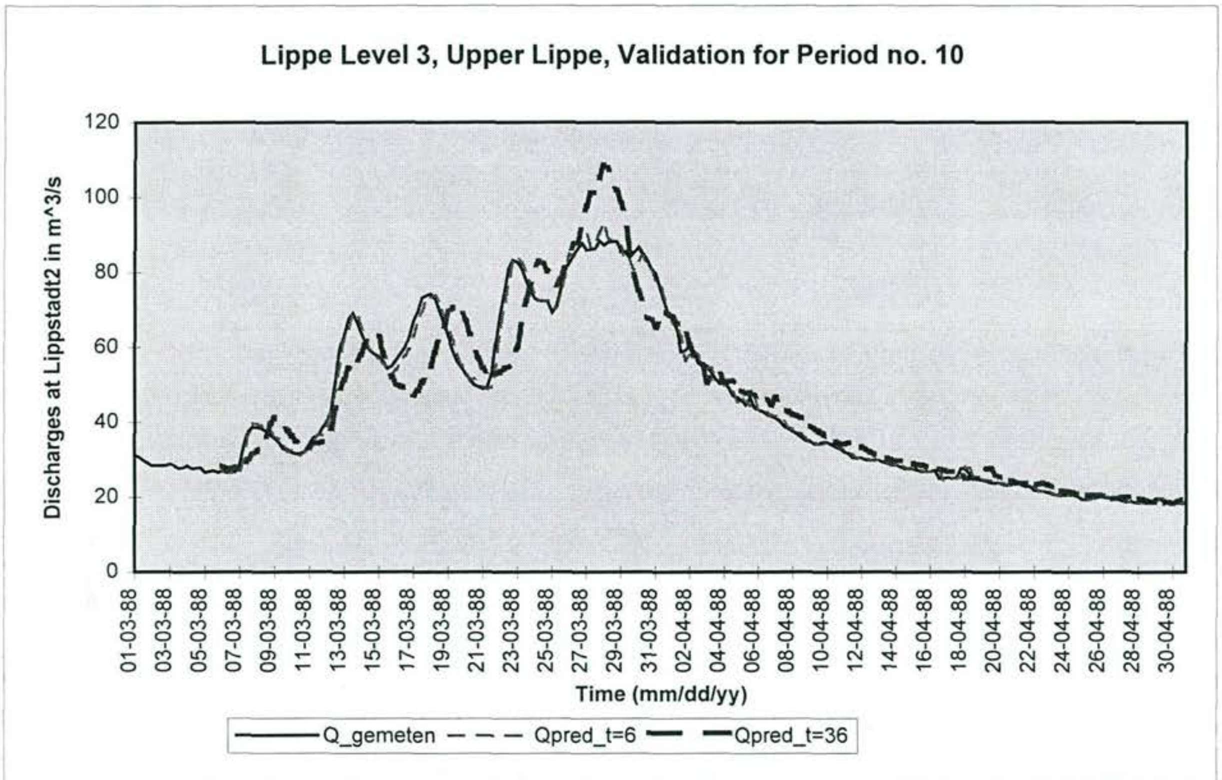


Model parameters			
fmin	0.35	alfa (1,1)	0.20
fmax	5.00	alfa (1,2)	0.10
kb	0.10	alfa (1,3)	0.00
psi	0.98	alfa (1,4)	0.00
kn	35.00	alfa (1,5)	0.00
nn	2.10	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00
		alfa (1,9)	0.00
		alfa (1.10)	0.00

Fig. 9.42. Lippe at Lippstadt2, Lippe Level 3, Upper Lippe basin, Calibration for Period no. 9.

SUMMARY OF VALIDATION RESULTS:

Prediction in hours in advance	Mean Absolute Efficiency	Maximum Local Efficiency	Minimum Local Efficiency
6	2.0%	11.0%	-9.1%
12	3.8%	17.9%	-10.5%
18	5.4%	23.5%	-16.2%
24	6.9%	27.7%	-20.6%
30	8.2%	31.7%	-25.4%
36	9.4%	32.8%	-28.3%

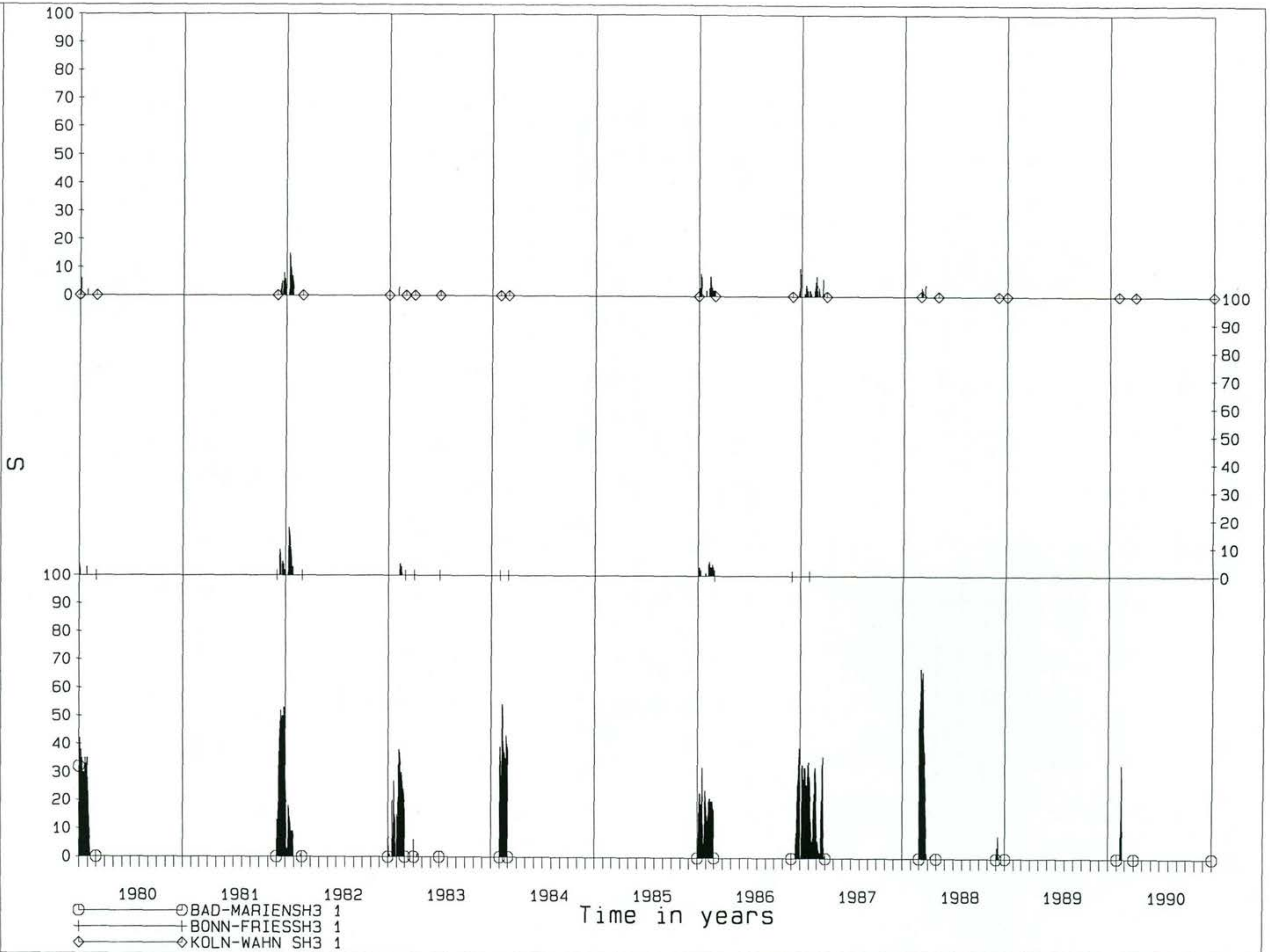


Model parameters			
fmin	0.35	alfa (1,1)	0.20
fmax	5.00	alfa (1,2)	0.10
kb	0.10	alfa (1,3)	0.00
psi	0.98	alfa (1,4)	0.00
kn	35.00	alfa (1,5)	0.00
nn	2.10	alfa (1,6)	0.00
		alfa (1,7)	0.00
		alfa (1.8)	0.00
		alfa (1,9)	0.00
		alfa (1.10)	0.00

Fig. 9.43. Lippe at Lippstadt2, Lippe Level 3, Upper Lippe basin, Validation for Period no. 10.

DELFT HYDRAULICS

Observed snowheights in the Sieg basin

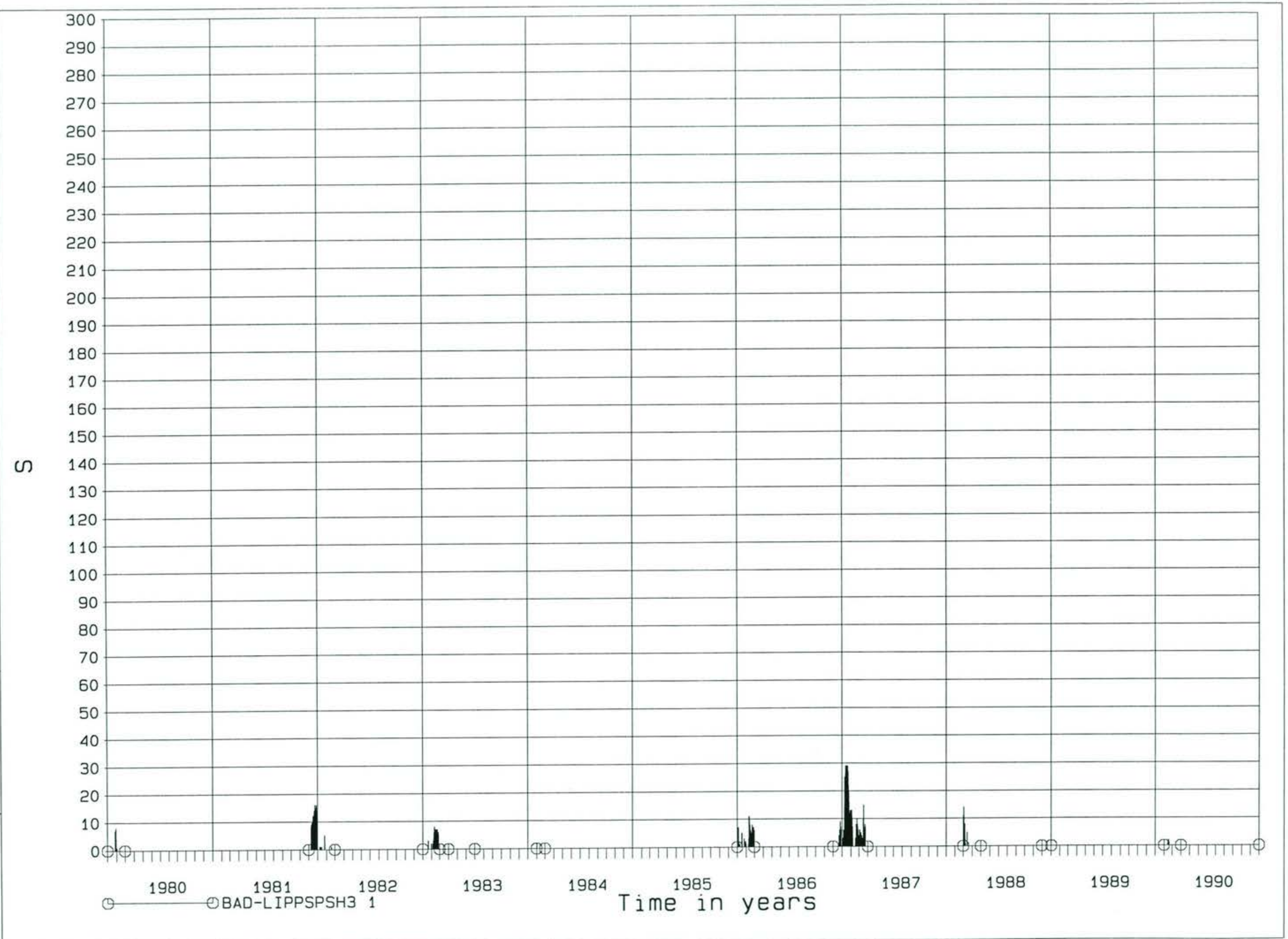


R3049

FIG. 9.44

DELFT HYDRAULICS

Observed snowheights in Lippe basin

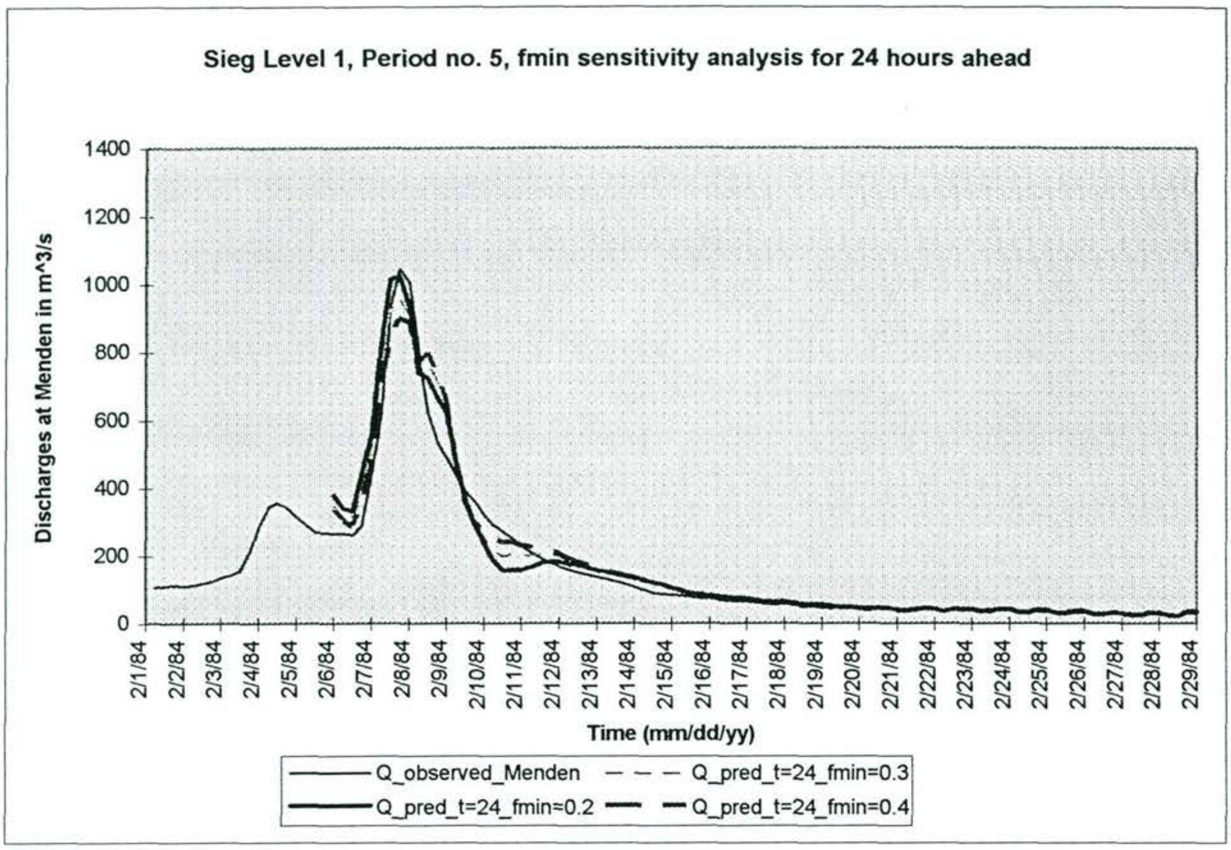


R3049

FIG. 9.45

Figures of Chapter 10

Figures of Chapter 10 (continued)



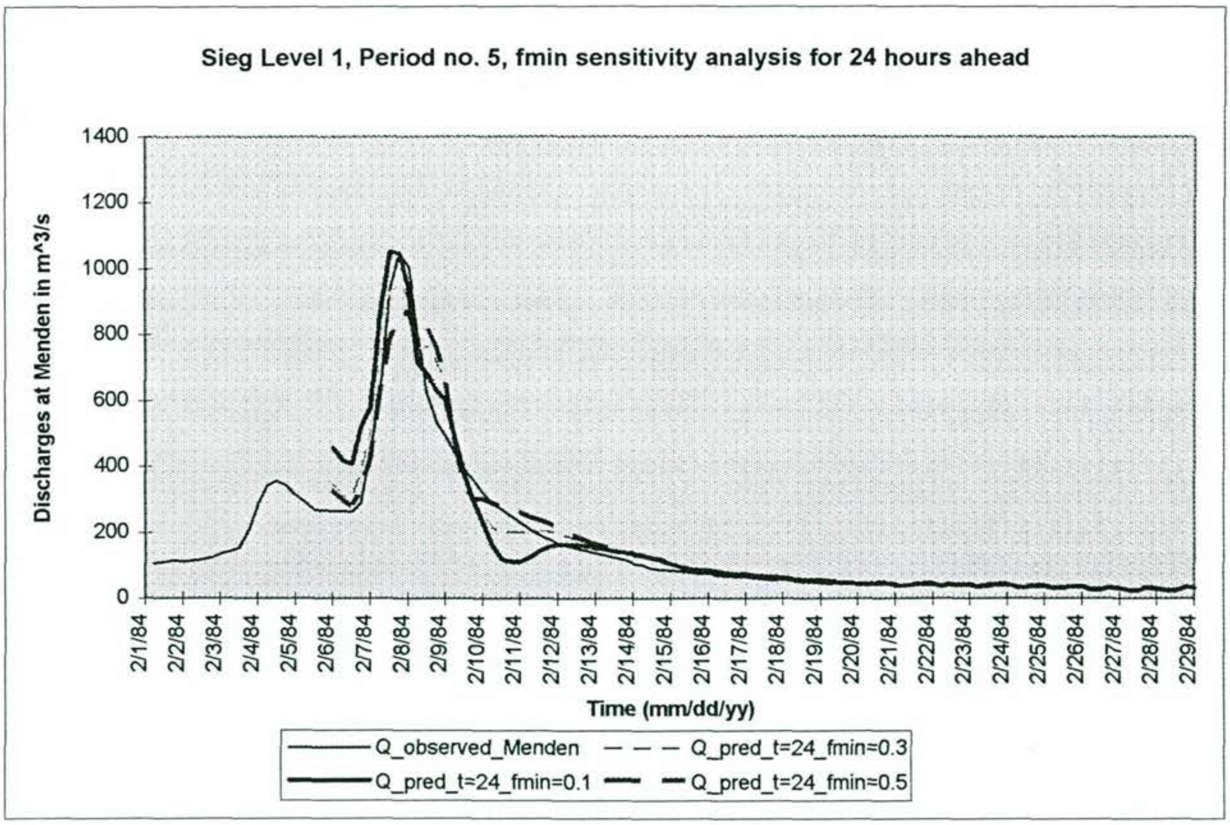
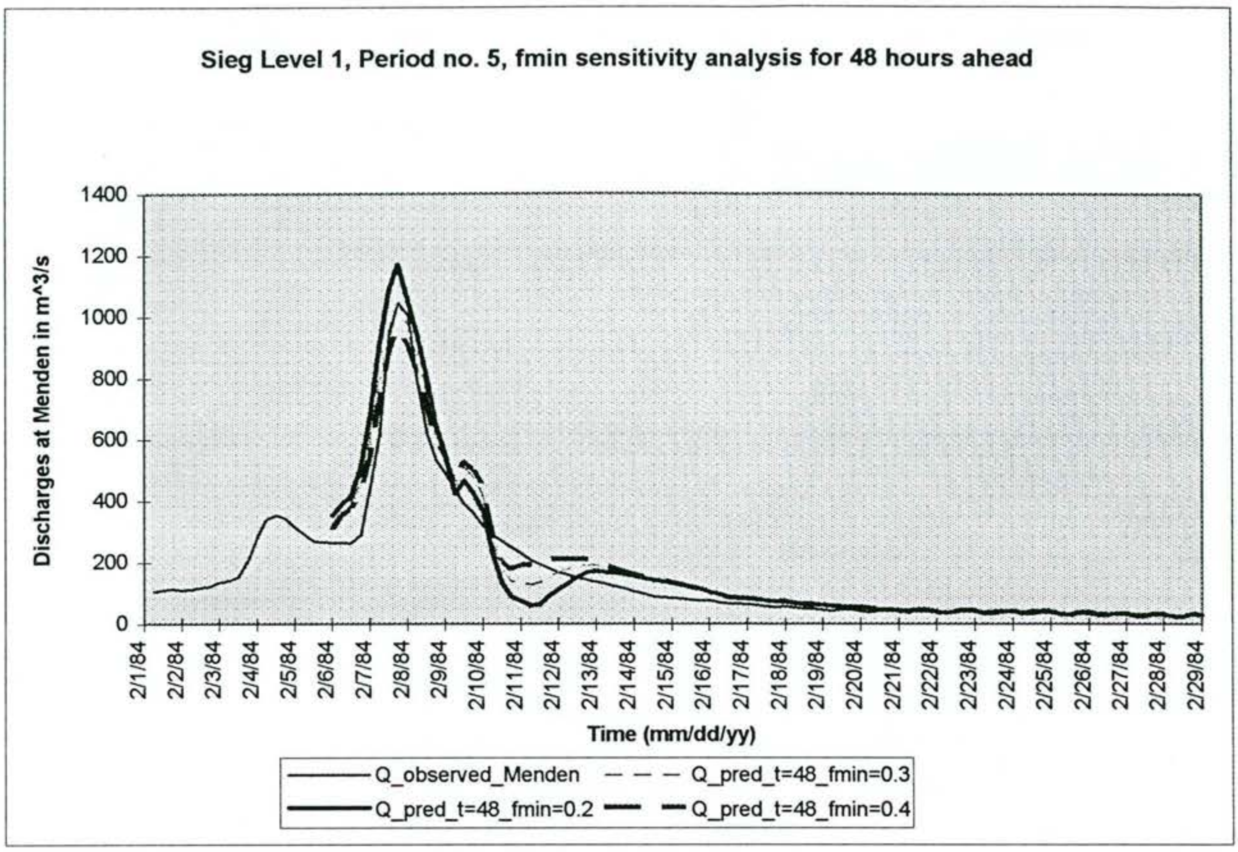


Fig. 10.1a Sieg Level 1, Period no. 5, Results of sensitivity for the minimum infiltration capacity f_{min} for 24 hours ahead.



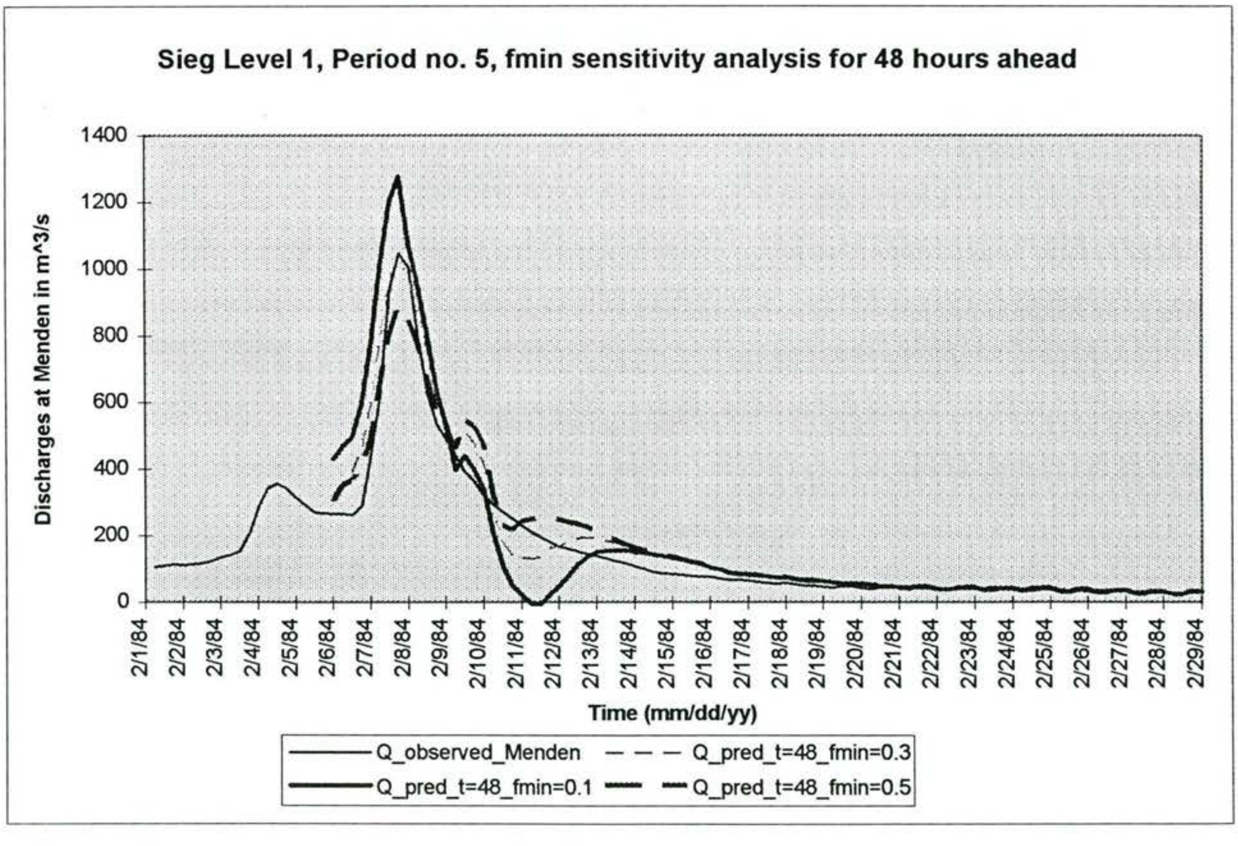
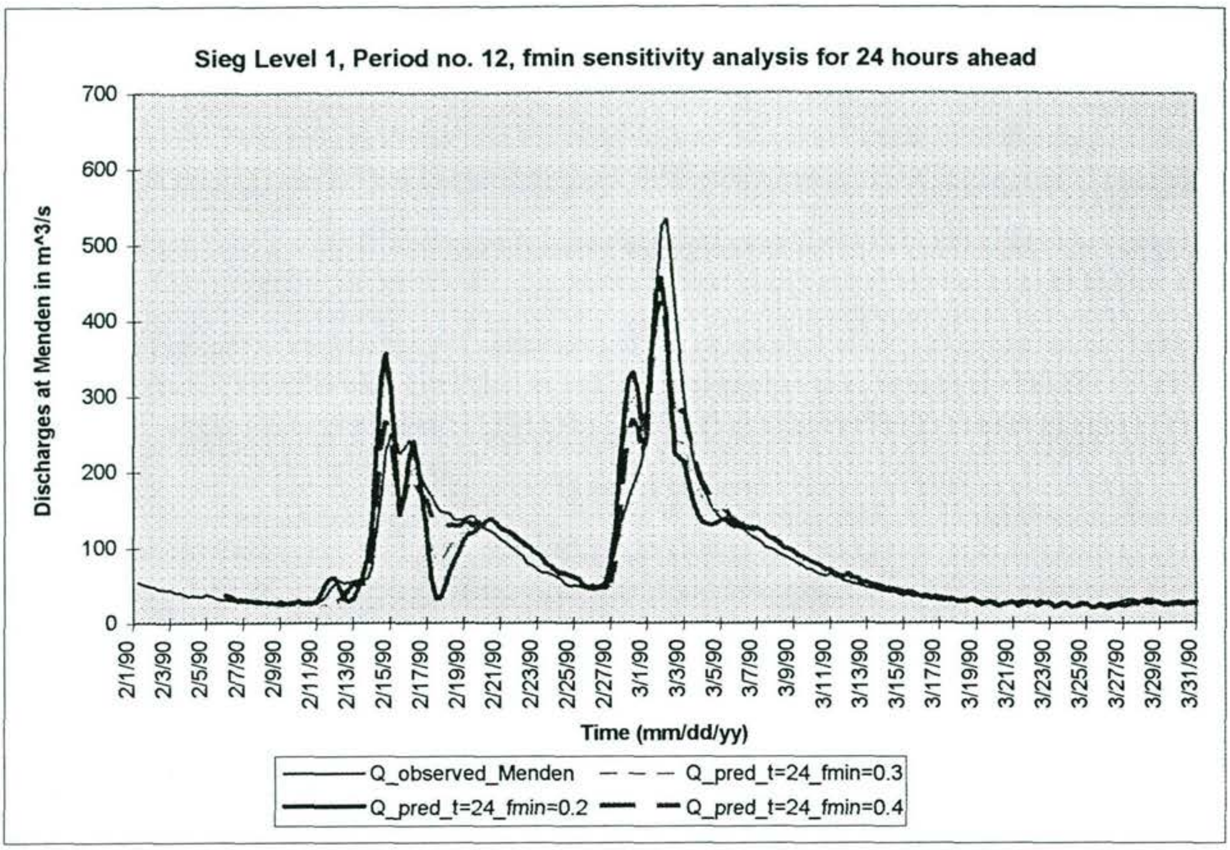


Fig. 10.1b Sieg Level 1, Period no. 5, Results of sensitivity for the minimum infiltration capacity f_{min} for 48 hours ahead.



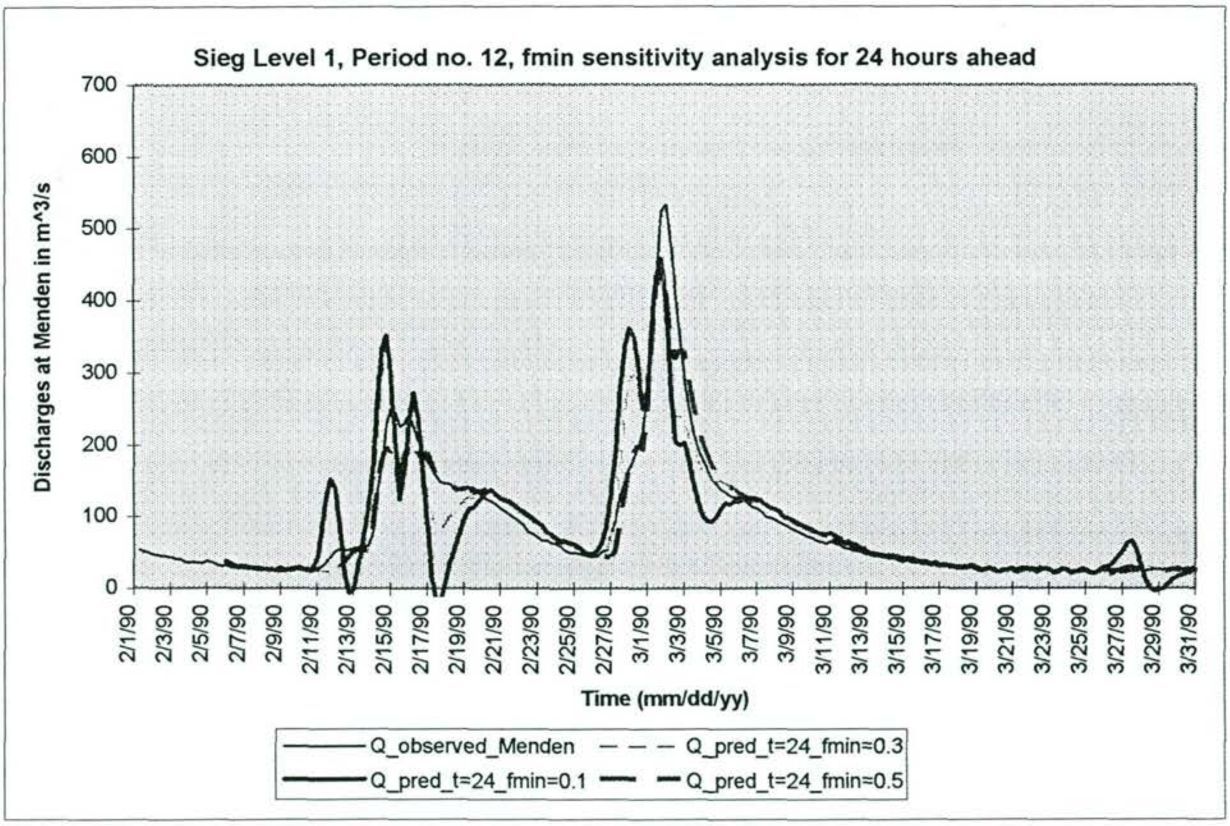
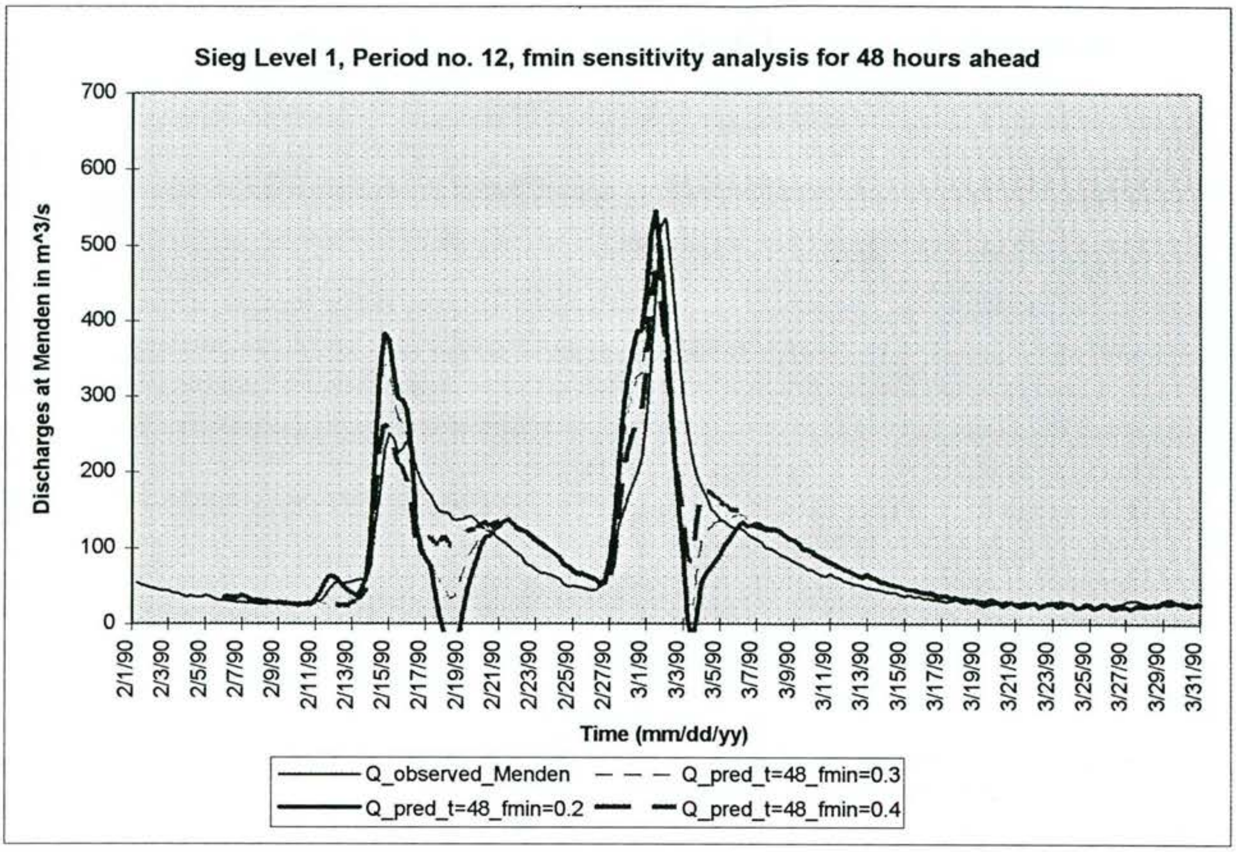


Fig. 10.2a Sieg Level 1, Period no. 12, Results of sensitivity for the minimum infiltration capacity f_{min} for 24 hours ahead.



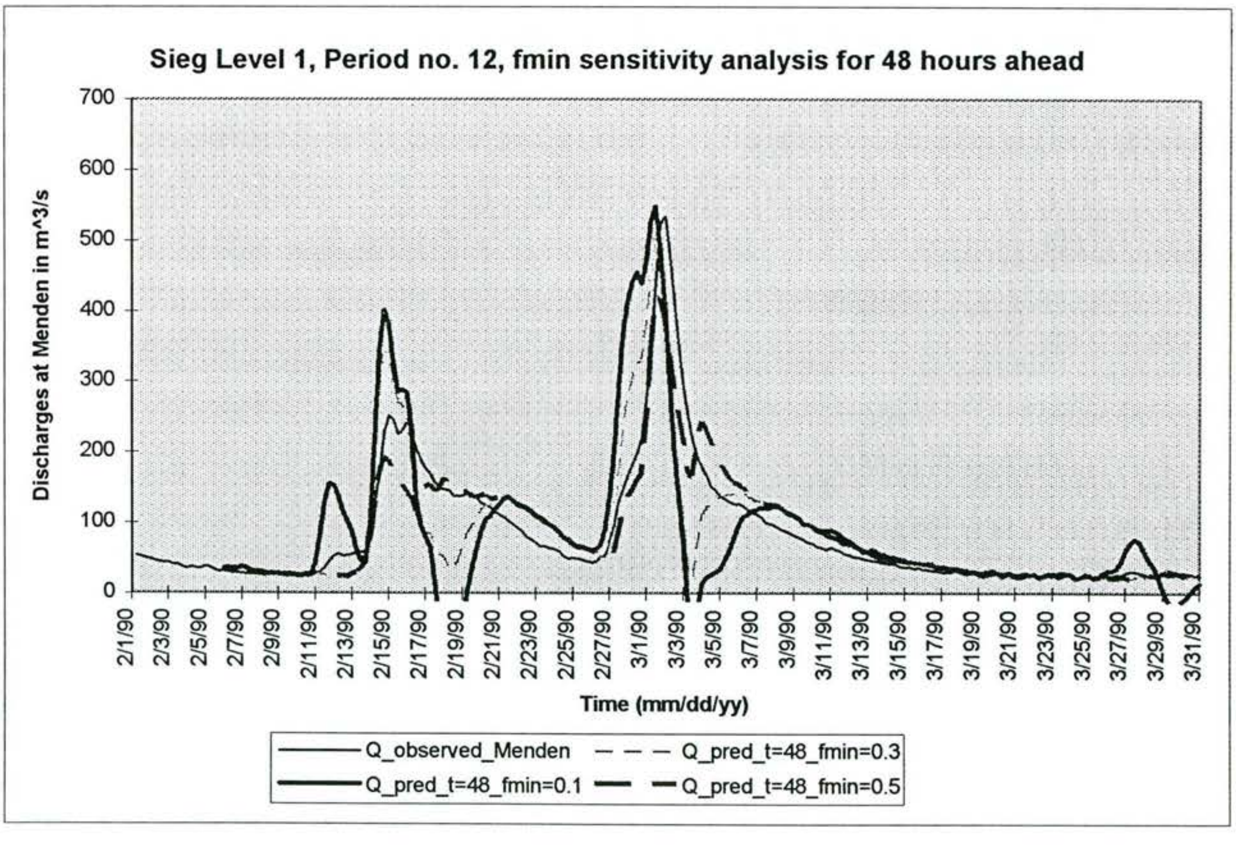
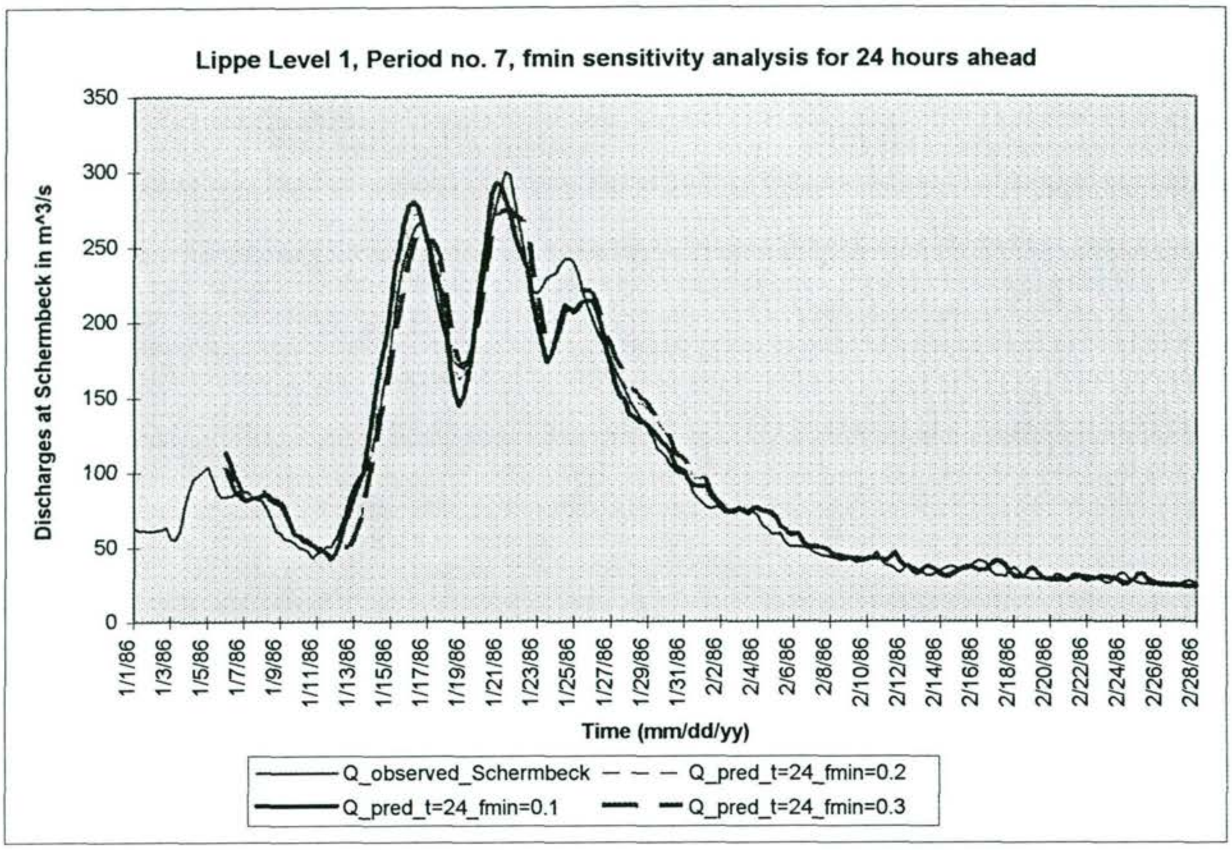


Fig. 10.2b Sieg Level 1, Period no. 12, Results of sensitivity for the minimum infiltration capacity f_{min} for 48 hours ahead.



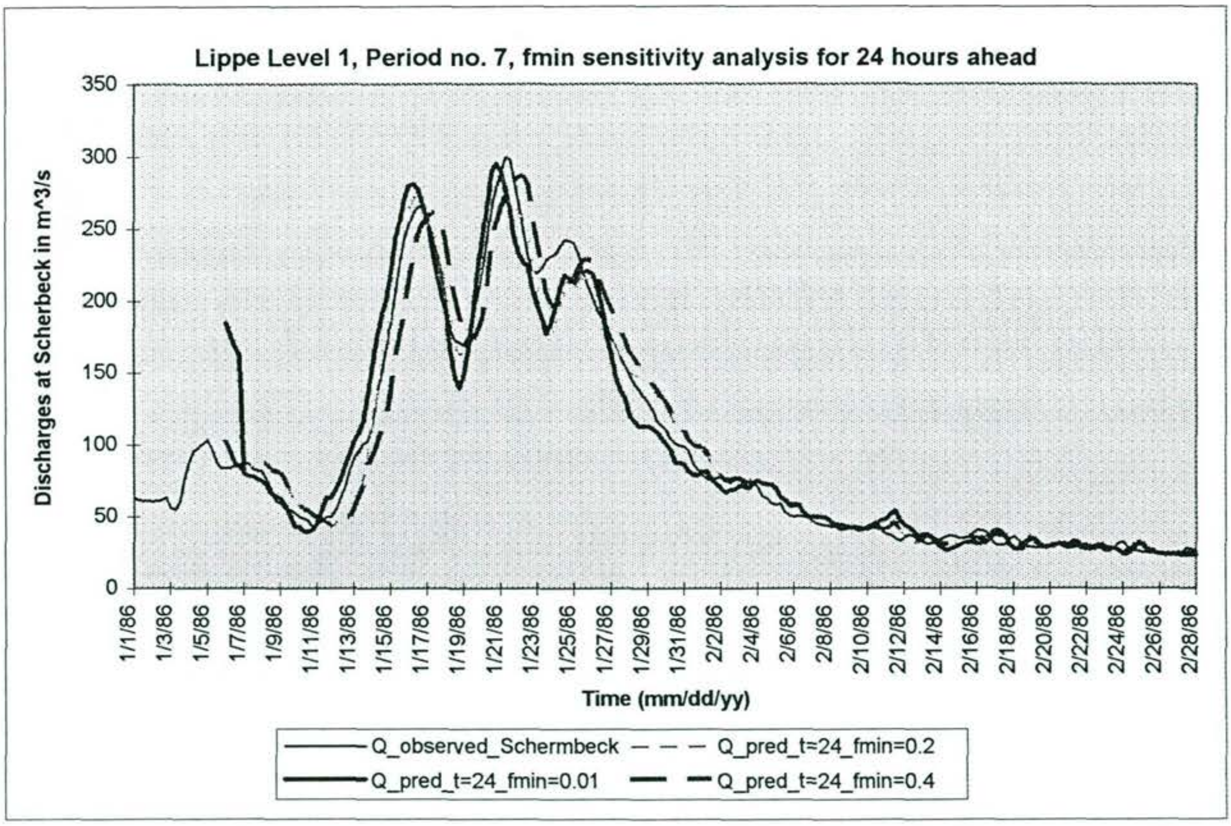
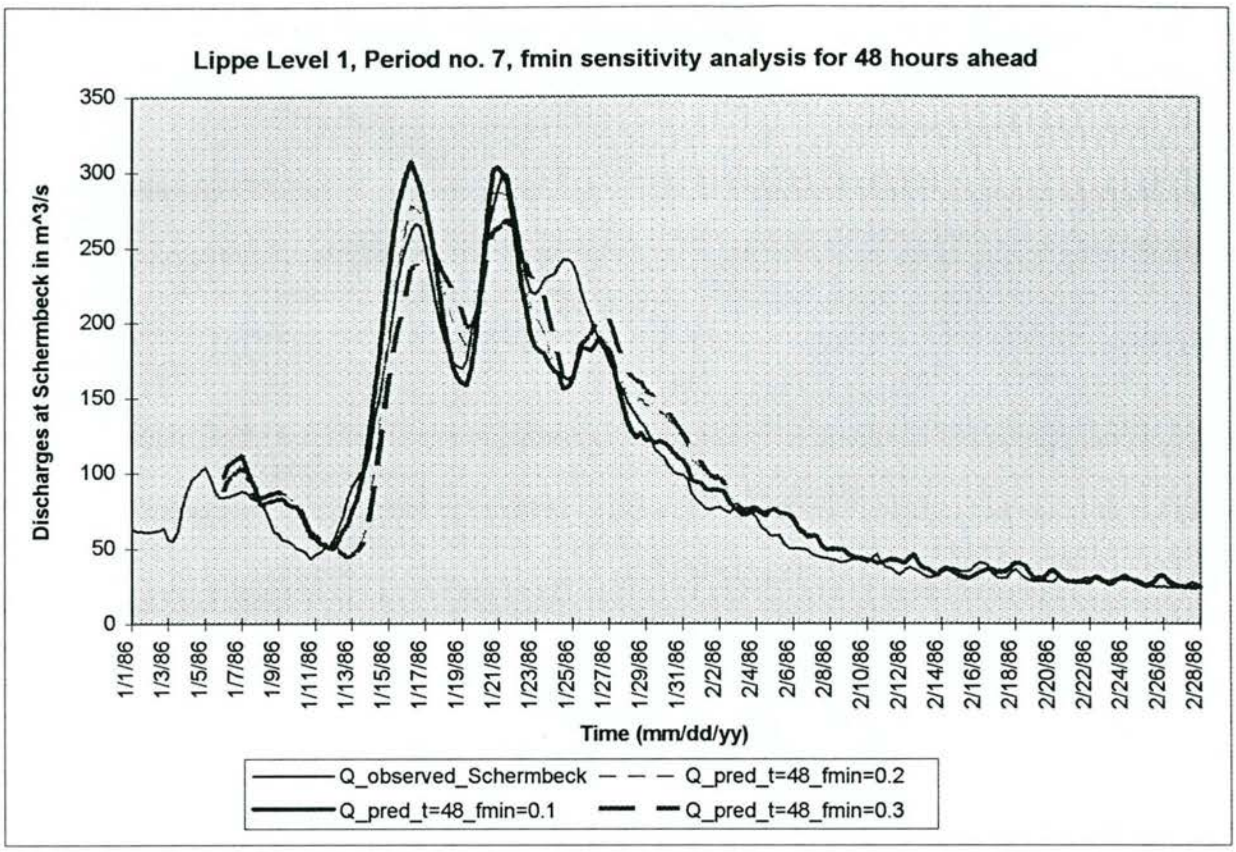


Fig. 10.3a Lippe Level 1, Period no. 7, Results of sensitivity for the minimum infiltration capacity f_{min} for 24 hours ahead.



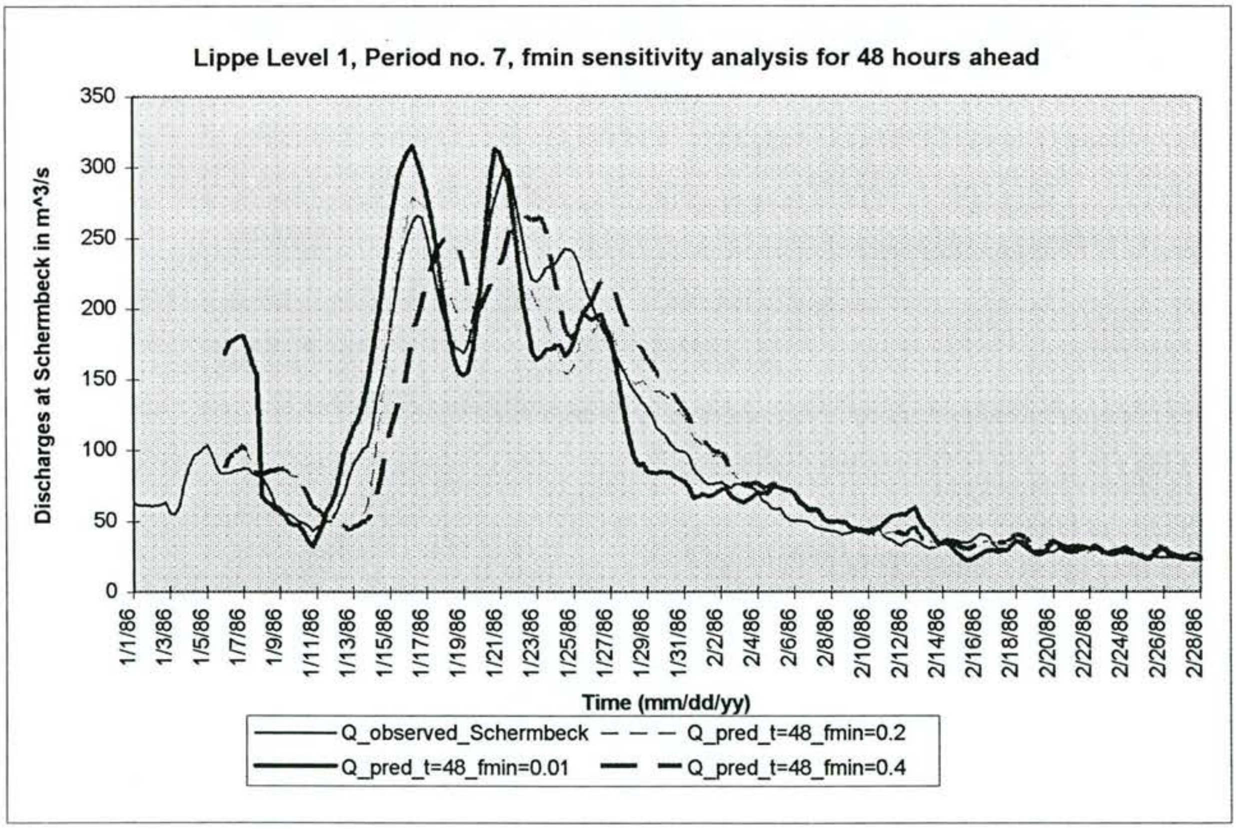
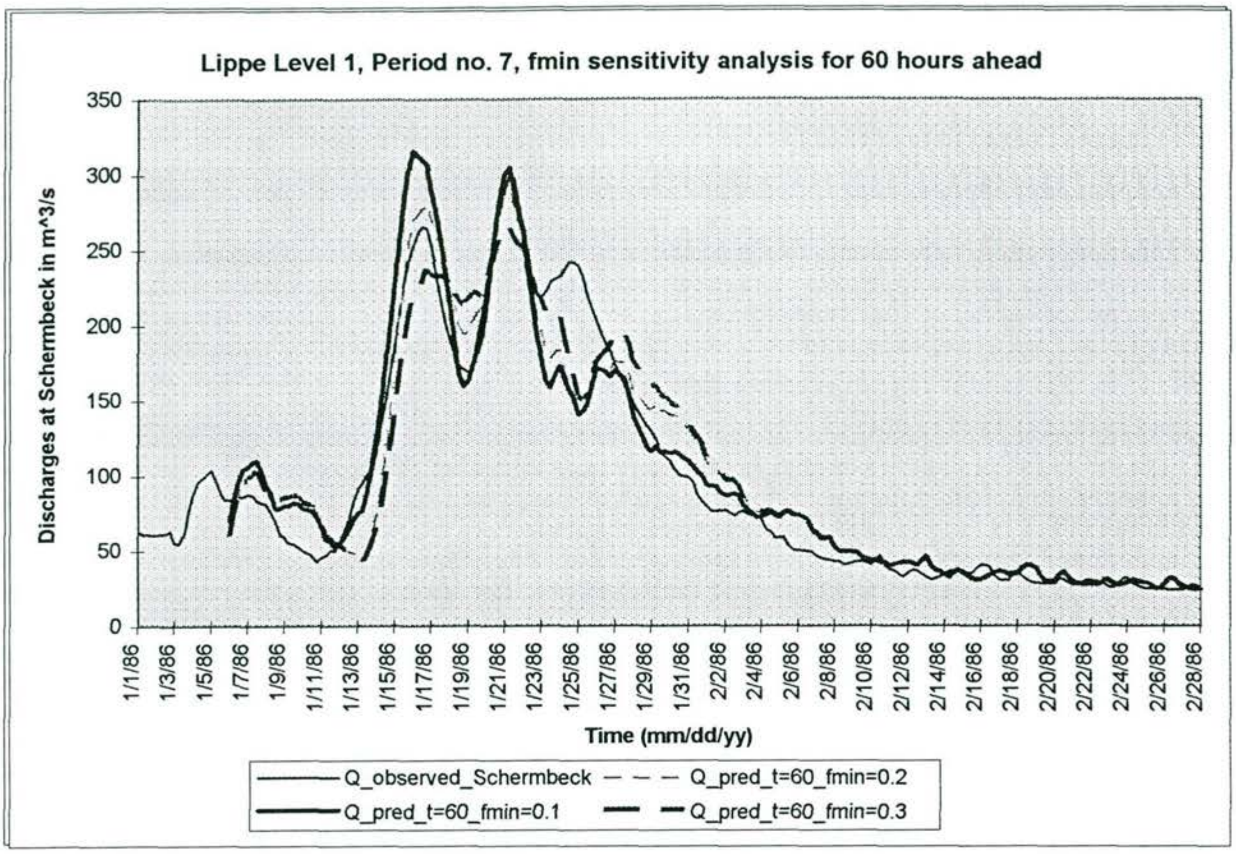


Fig. 10.3b Lippe Level 1, Period no. 7, Results of sensitivity for the minimum infiltration capacity f_{min} for 48 hours ahead.



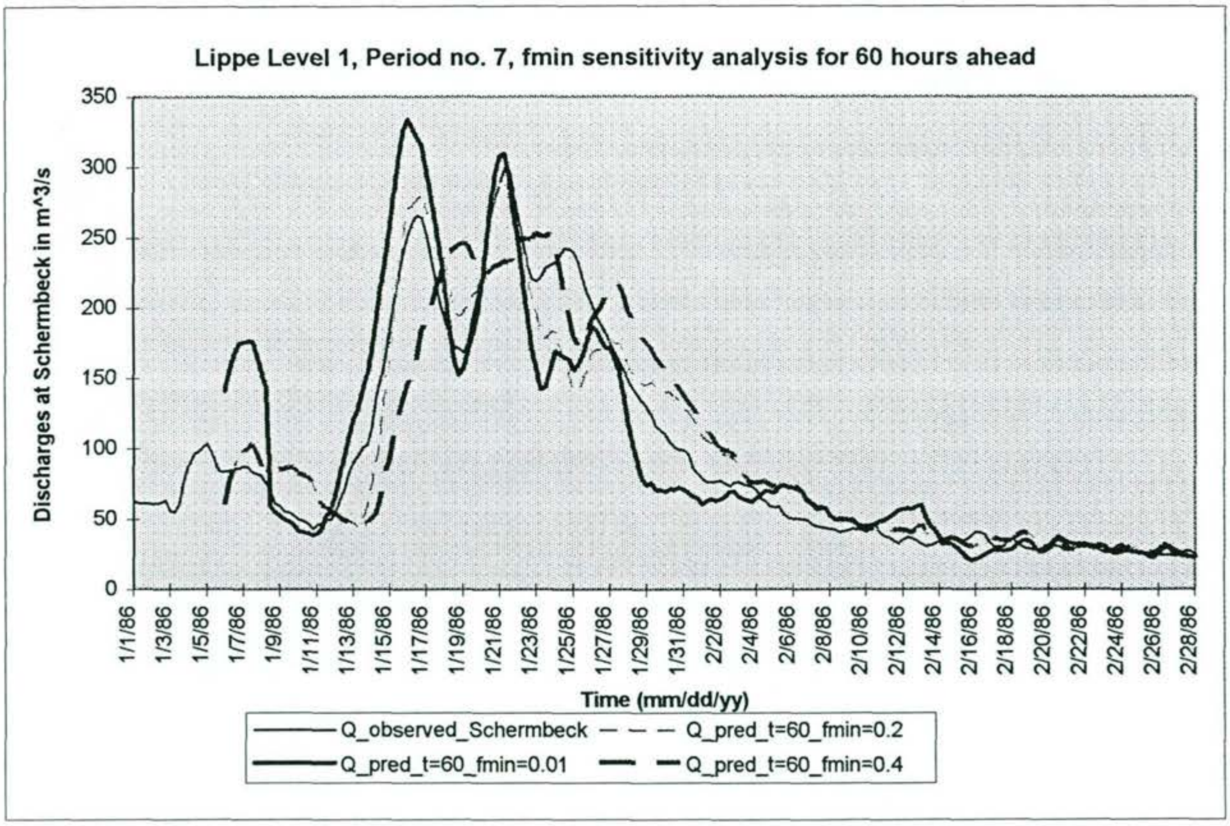
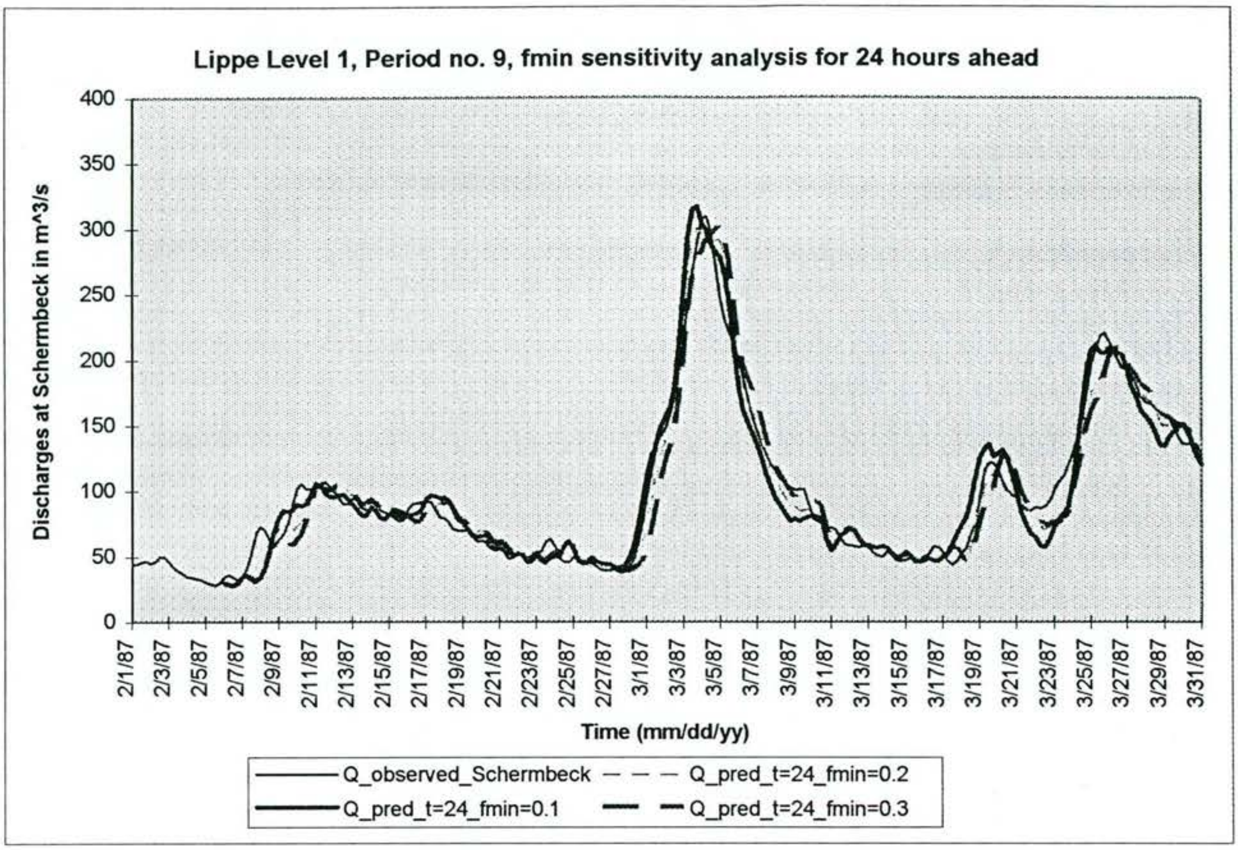


Fig. 10.3c Lippe Level 1, Period no. 7, Results of sensitivity for the minimum infiltration capacity f_{min} for 60 hours ahead.



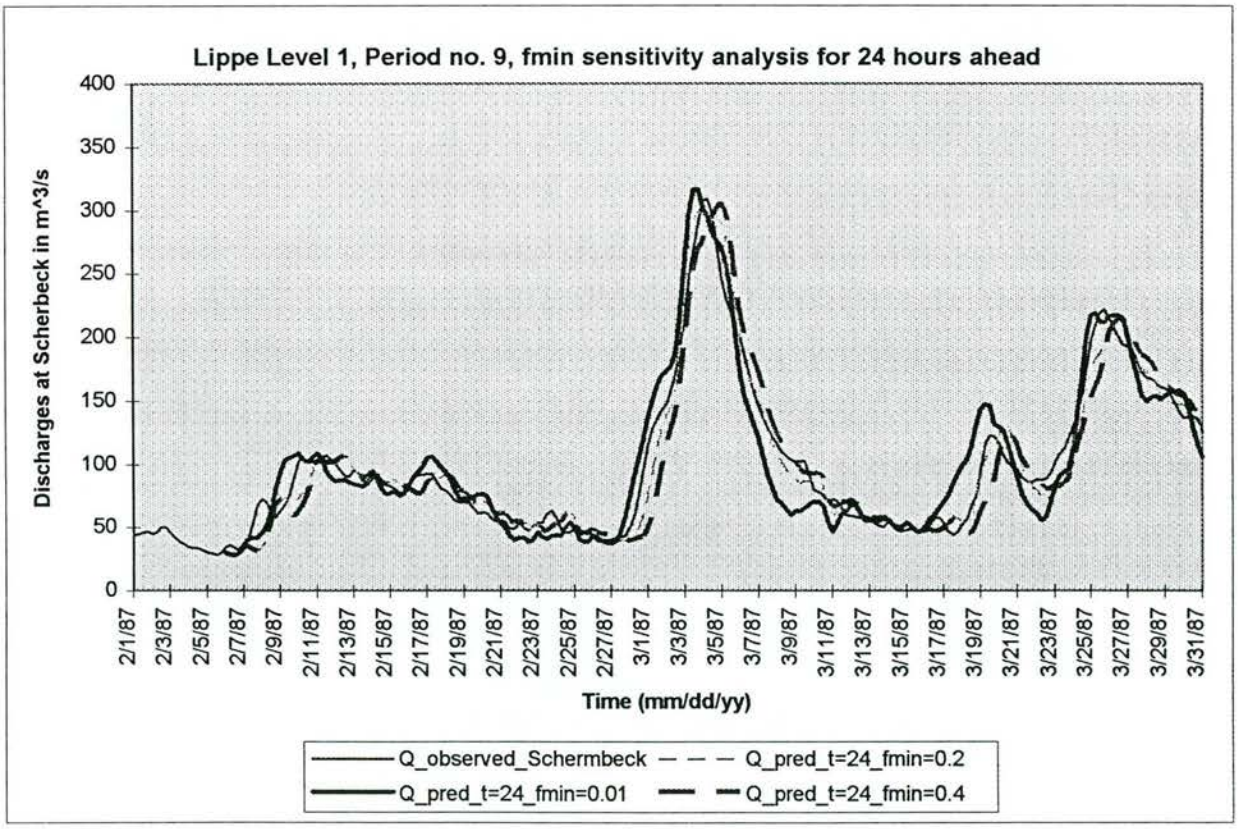
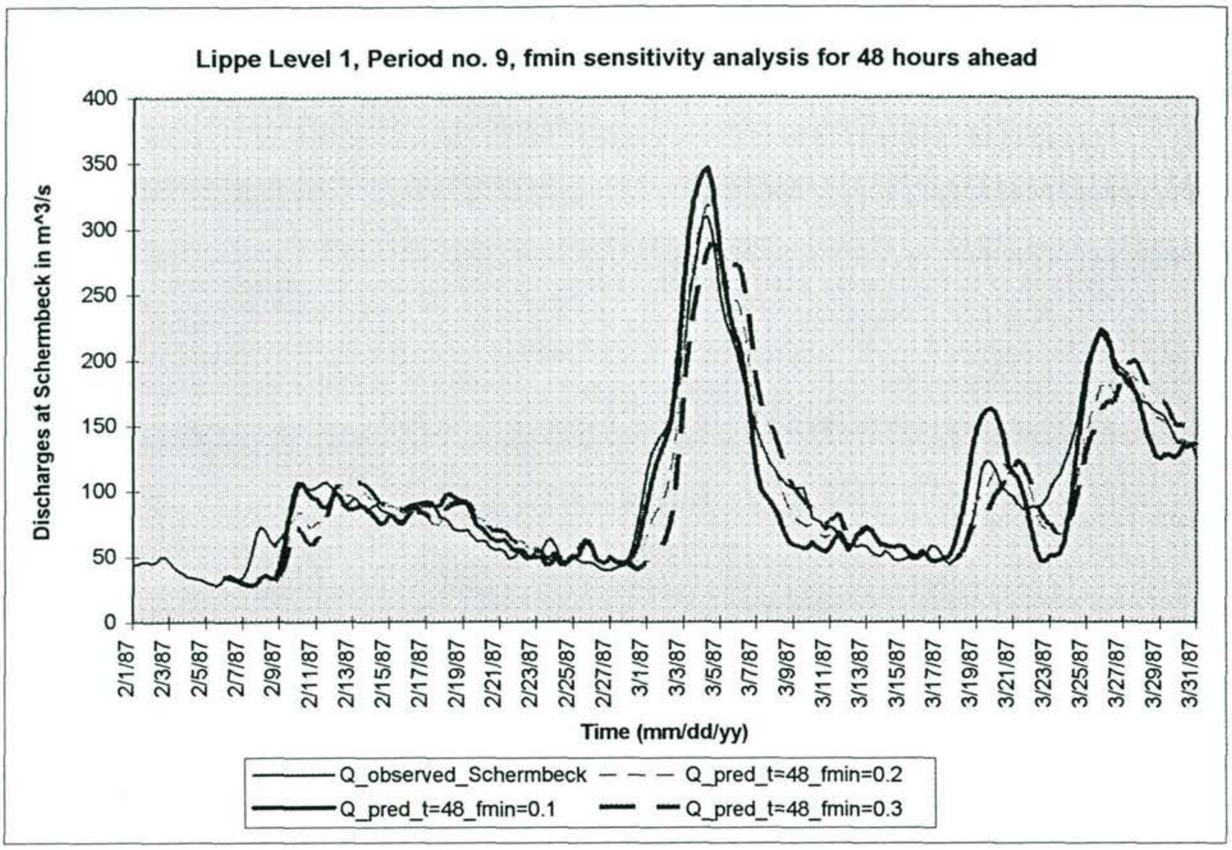


Fig. 10.4a Lippe Level 1, Period no. 9, Results of sensitivity for the minimum infiltration capacity f_{min} for 24 hours ahead



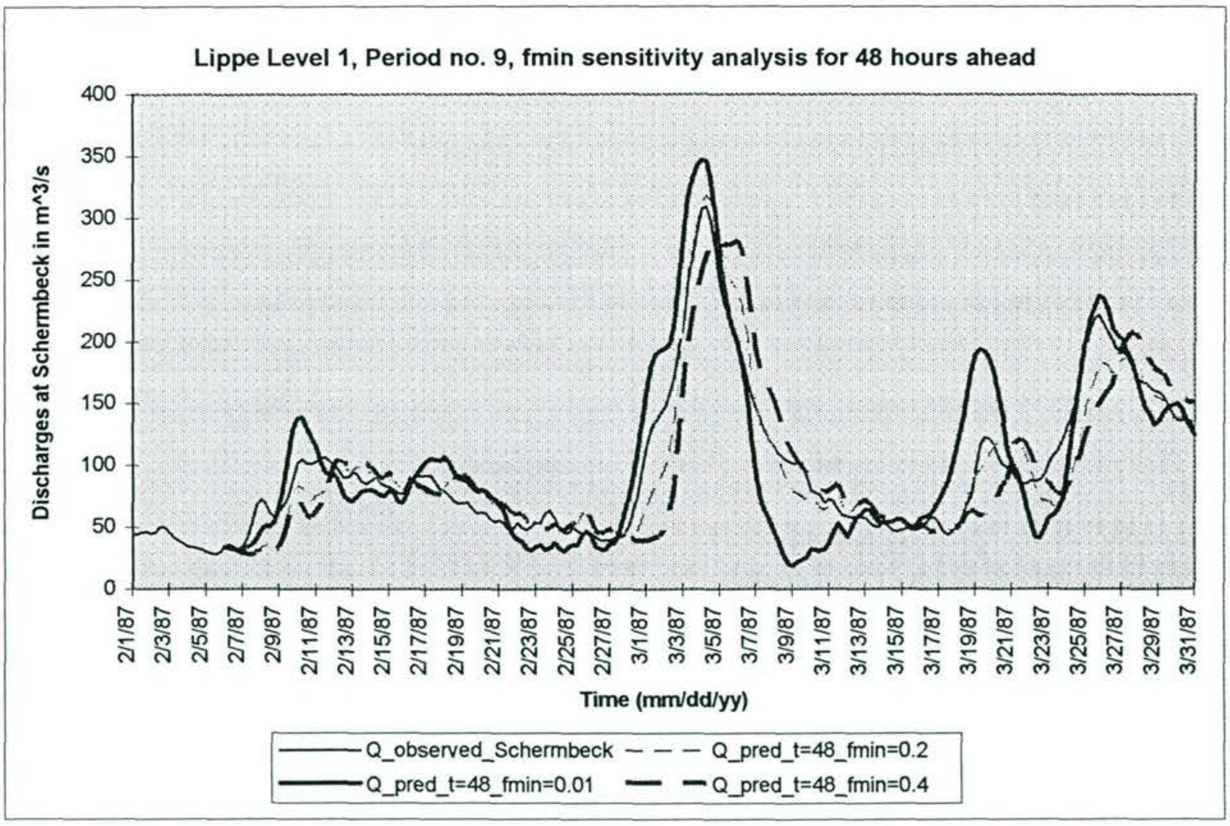
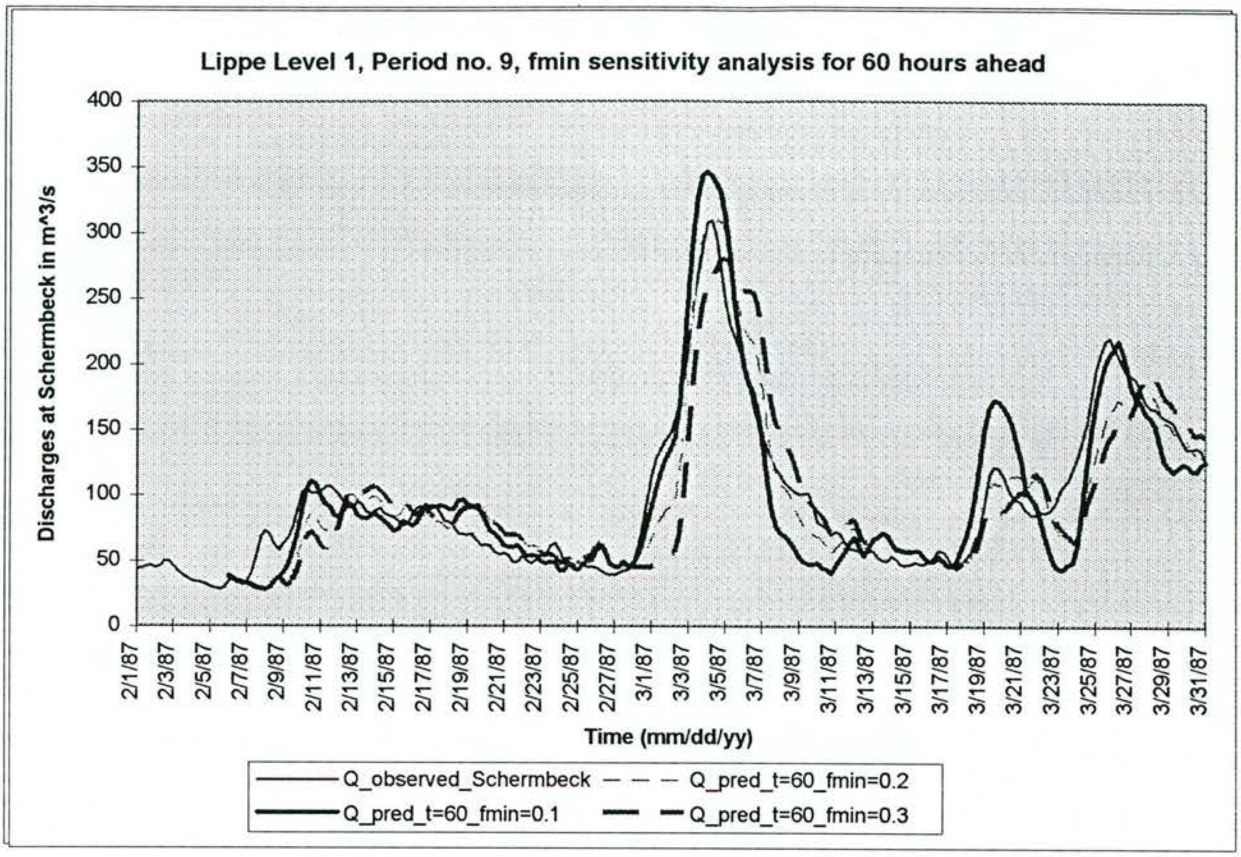


Fig. 10.4b Lippe Level 1, Period no. 9, Results of sensitivity for the minimum infiltration capacity f_{min} for 48 hours ahead



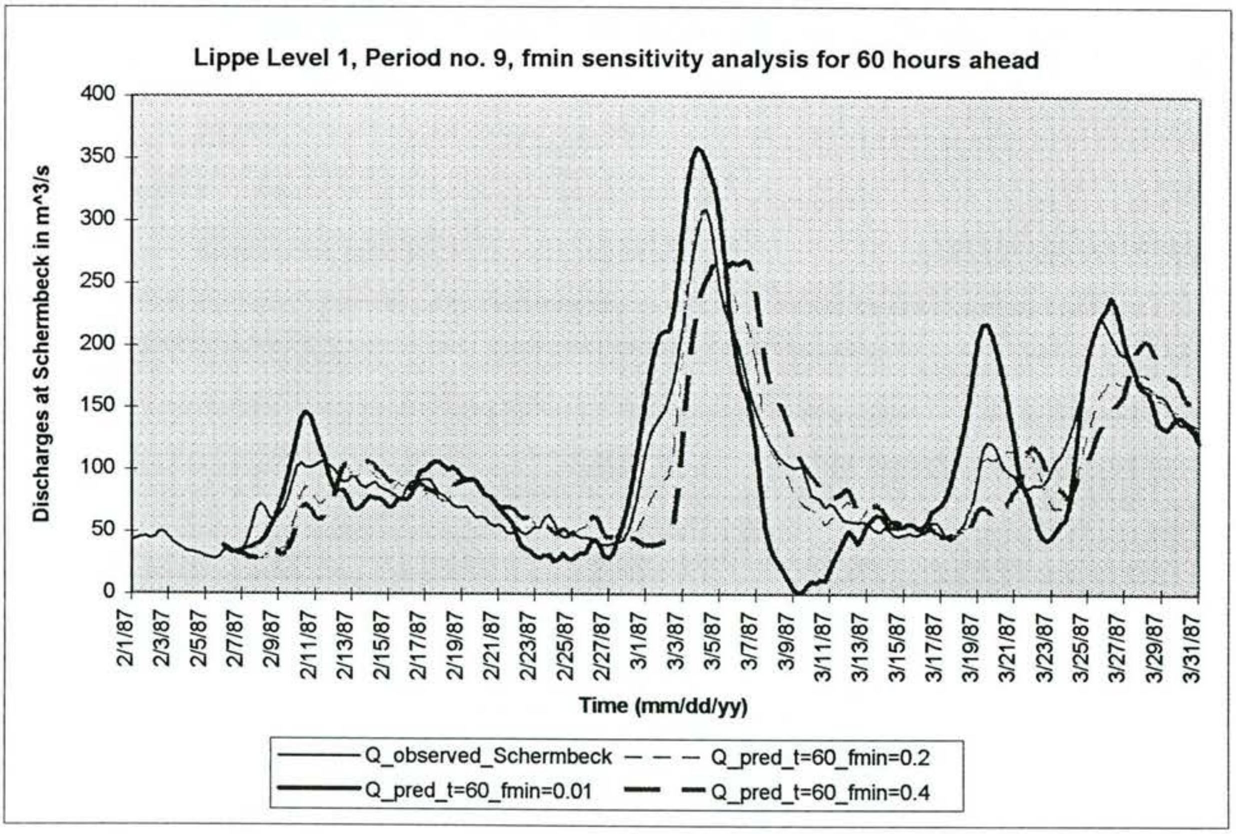
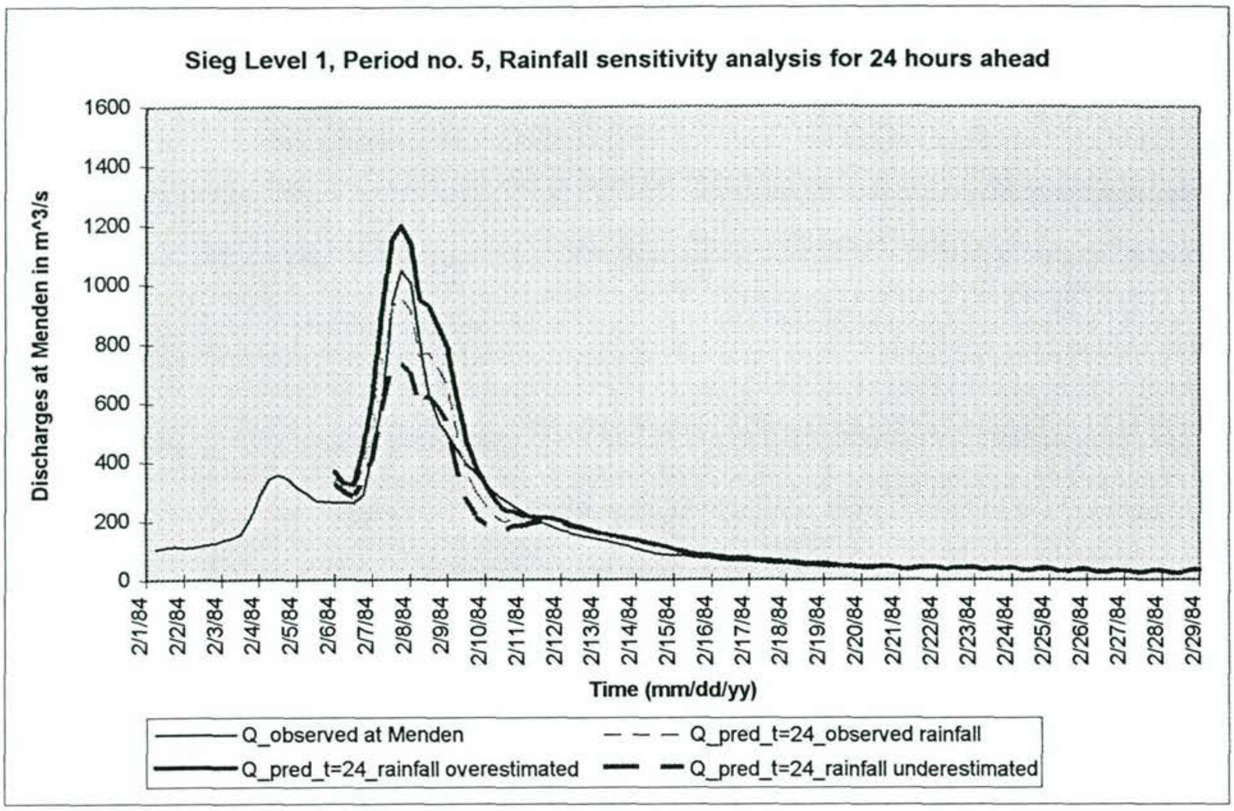
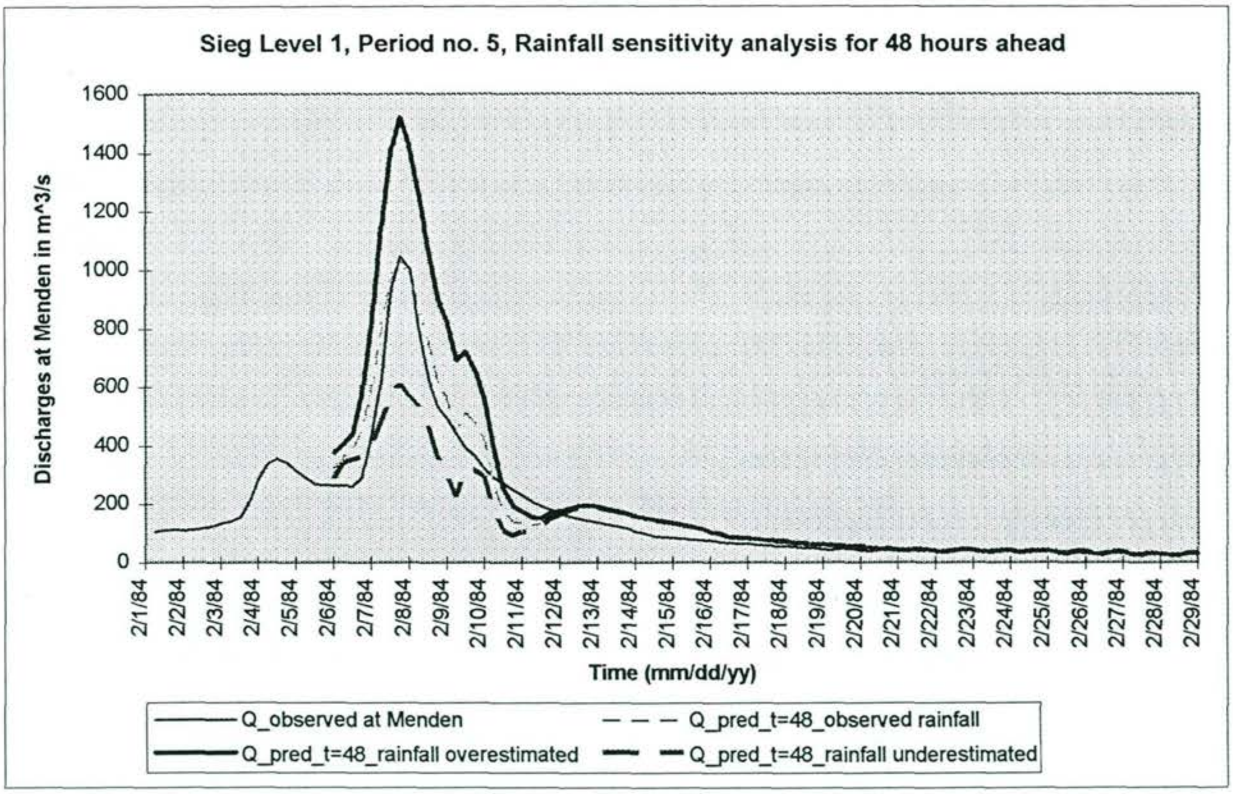


Fig. 10.4c Lippe Level 1, Period no. 9, Results of sensitivity for the minimum infiltration capacity f_{min} for 60 hours ahead

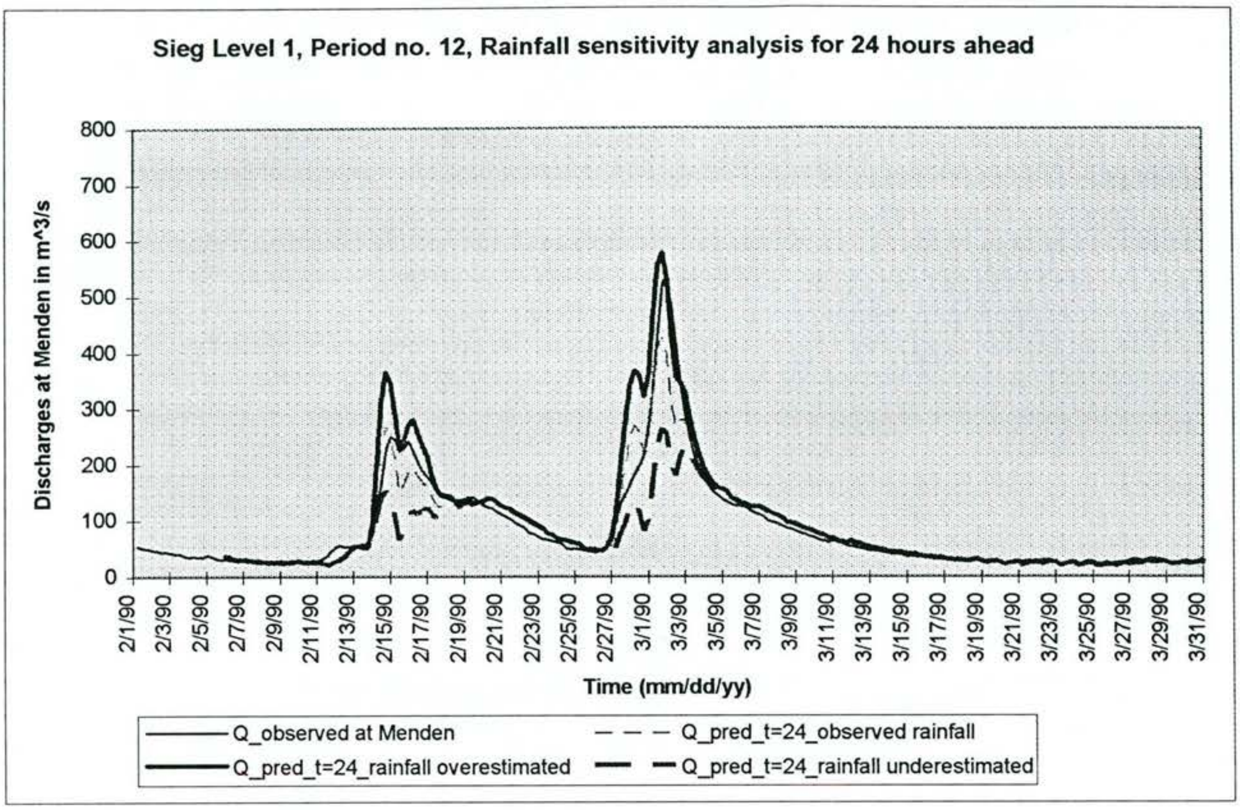


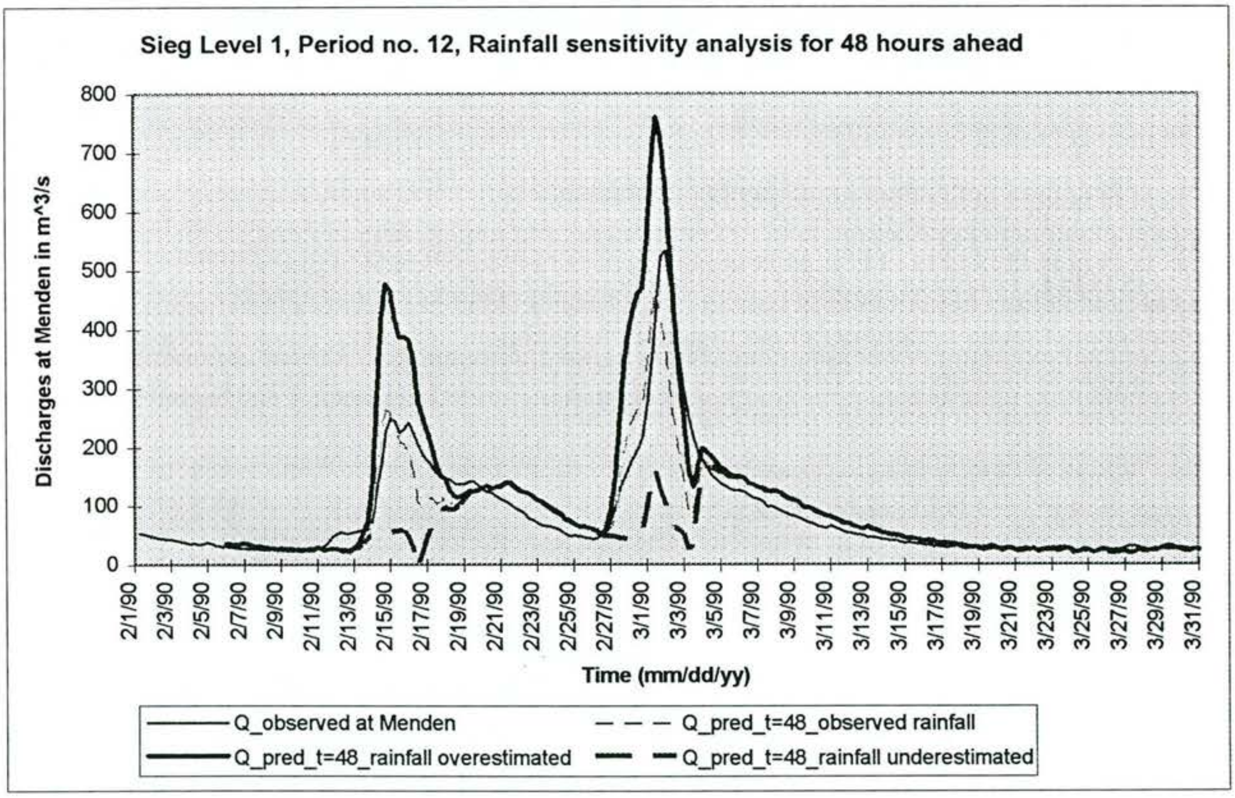


Notes:

1. Overestimation of forecasted rainfall refers to: +20% for $0<t<24$ and +40% for $24<t<48$ hours;
2. Underestimation of forecasted rainfall refers to: -20% for $0<t<24$ and -40% for $24<t<48$ hours;

Fig. 10.5 Sieg Level 1: Results of rainfall sensitivity analysis for Period no. 5.

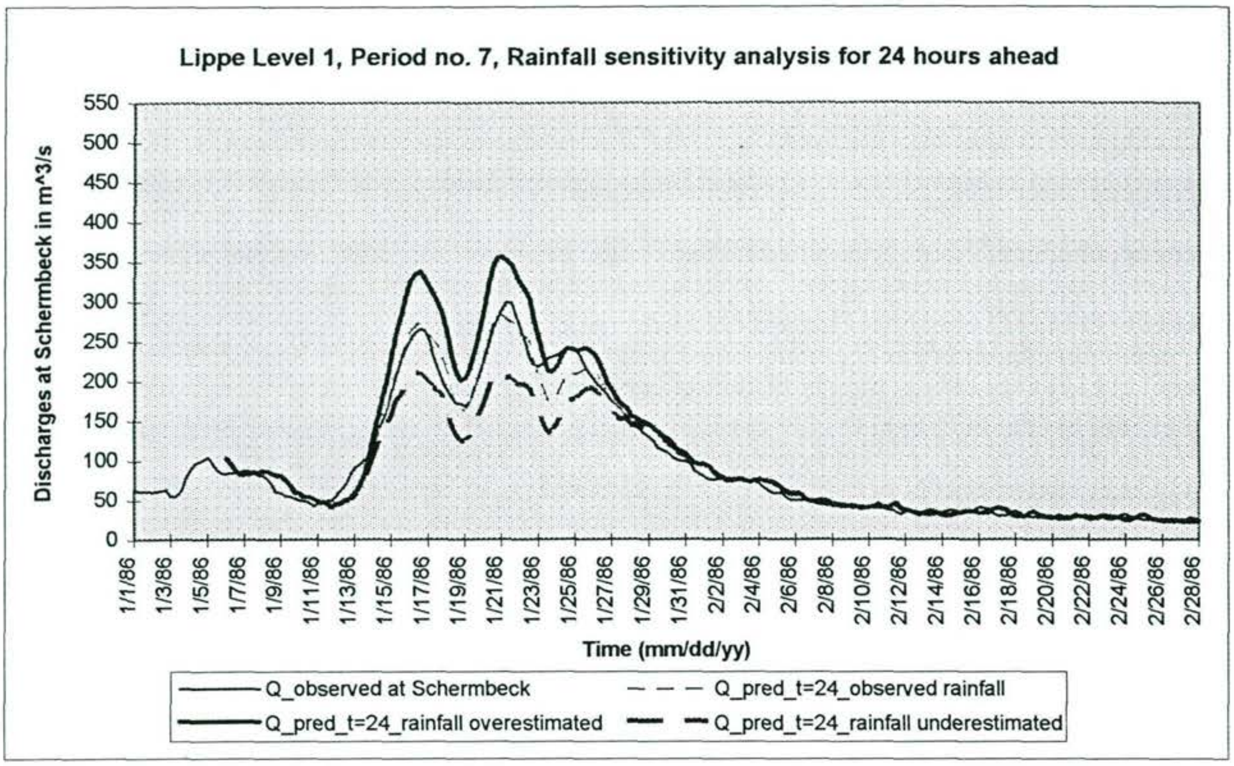


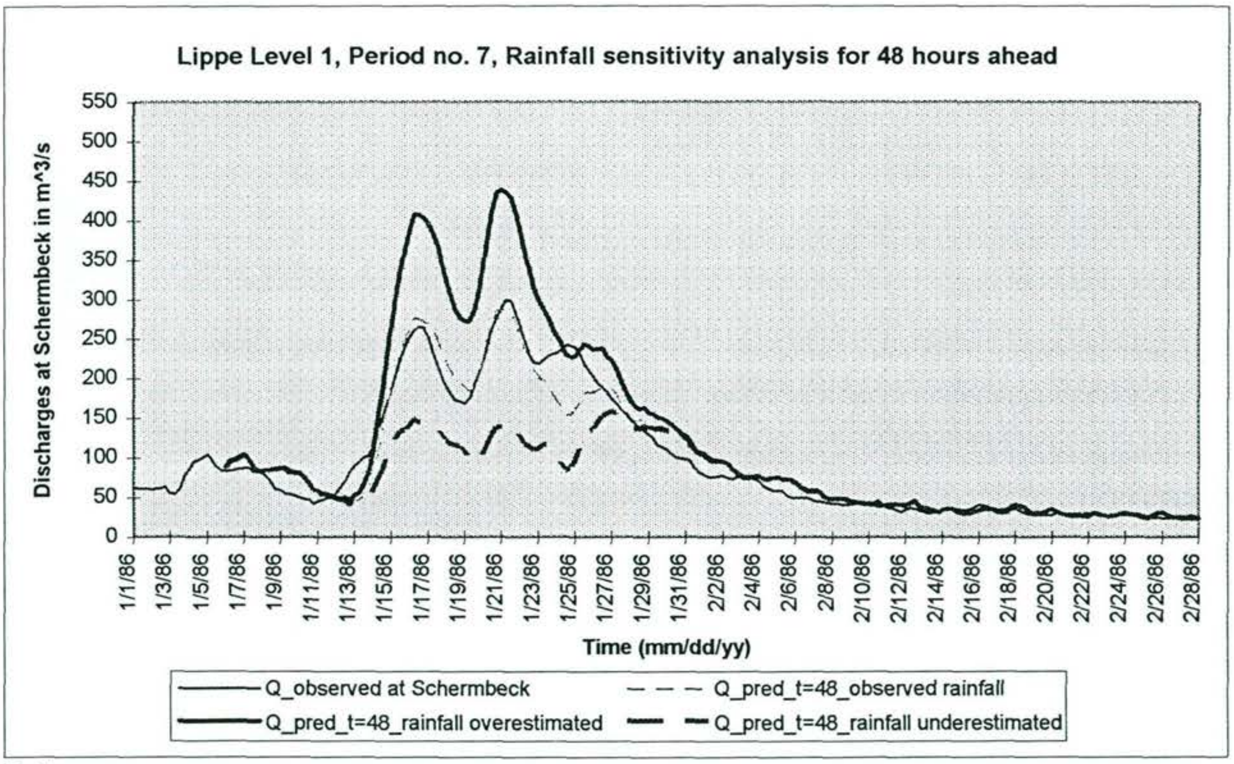


Notes:

1. Overestimation of forecasted rainfall refers to: +20% for 0<t<24 and +40% for 24<t<48 hours;
2. Underestimation of forecasted rainfall refers to: -20% for 0<t<24 and -40% for 24<t<48 hours;

Fig. 10.6 Sieg Level 1: Results of rainfall sensitivity analysis for Period no. 12.

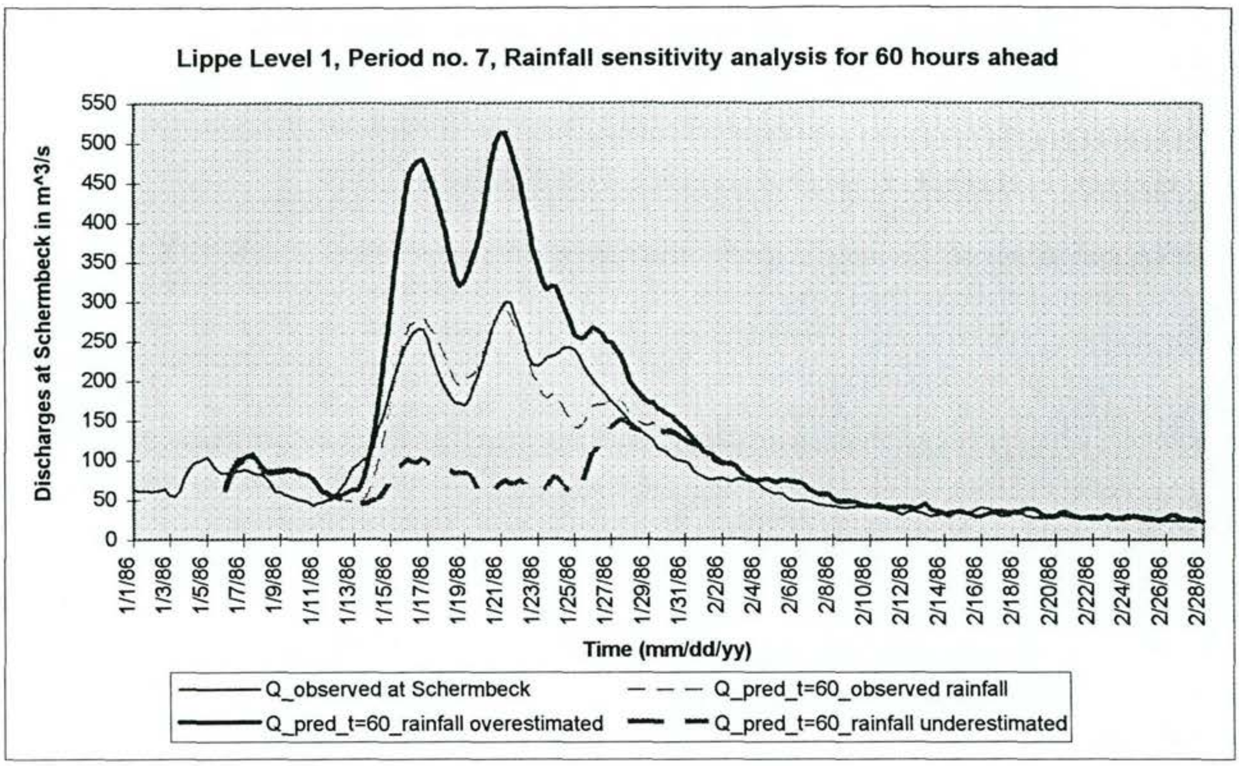




Notes:

1. Overestimation of forecasted rainfall refers to: +20% for $0<t<24$, +40% for $24<t<48$ hours, and +60% for $48<t<60$ hours.
2. Underestimation of forecasted rainfall refers to: -20% for $0<t<24$ and -40% for $24<t<48$ hours; and -60% for $48<t<60$ hours.

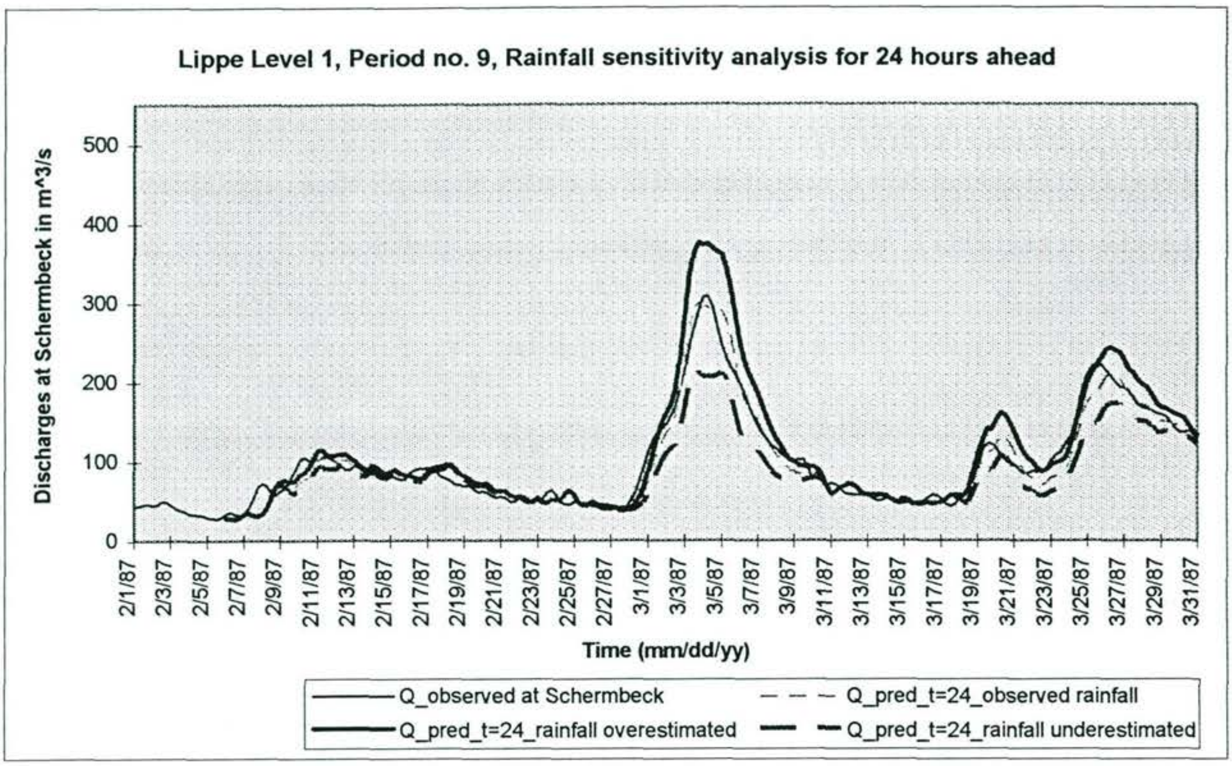
Fig. 10.7a Lippe Level 1: Results of rainfall sensitivity analysis for Period no. 7.

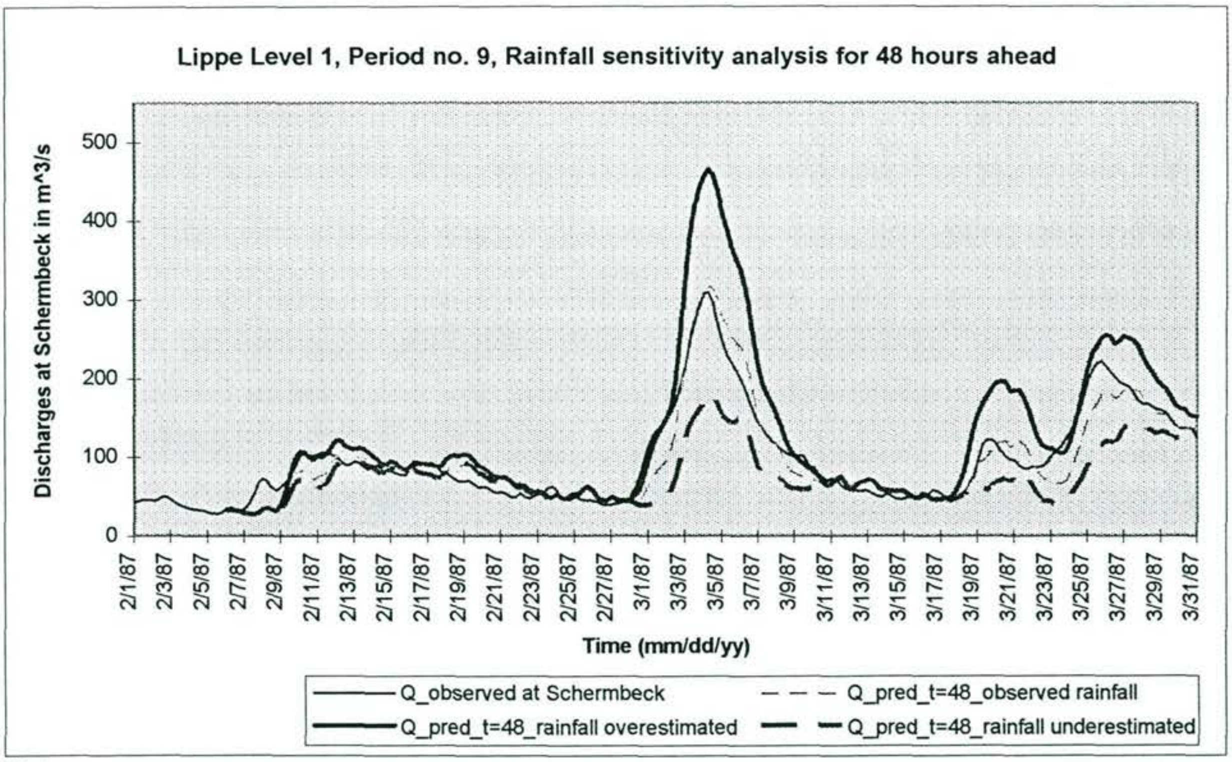


Notes:

1. Overestimation of forecasted rainfall refers to: +20% for 0<t<24, +40% for 24<t<48 hours, and +60% for 48<t<60 hours.
2. Underestimation of forecasted rainfall refers to: -20% for 0<t<24 and -40% for 24<t<48 hours; and -60% for 48<t<60 hours.

Fig. 10.7b Lippe Level 1: Results of rainfall sensitivity analysis for Period no. 7.

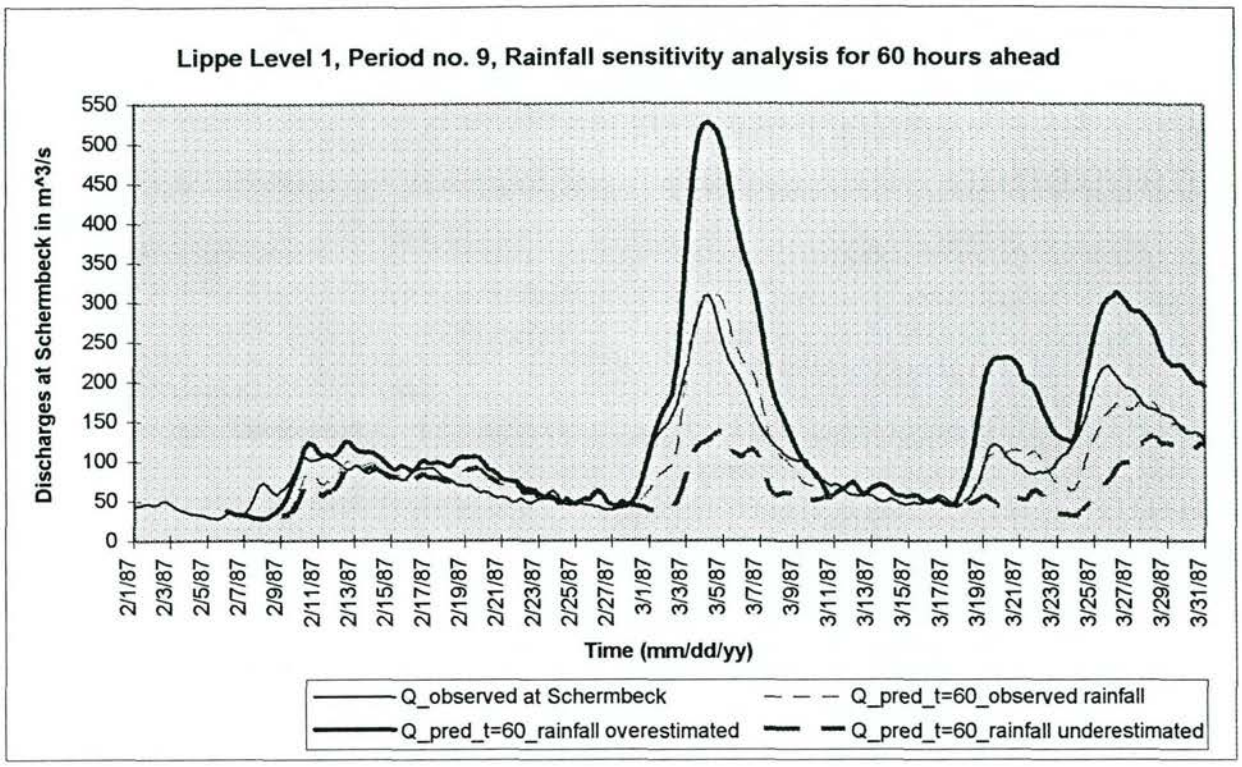




Notes:

1. Overestimation of forecasted rainfall refers to: +20% for $0<t<24$, +40% for $24<t<48$ hours, and +60% for $48<t<60$ hours.
2. Underestimation of forecasted rainfall refers to: -20% for $0<t<24$ and -40% for $24<t<48$ hours; and -60% for $48<t<60$ hours.

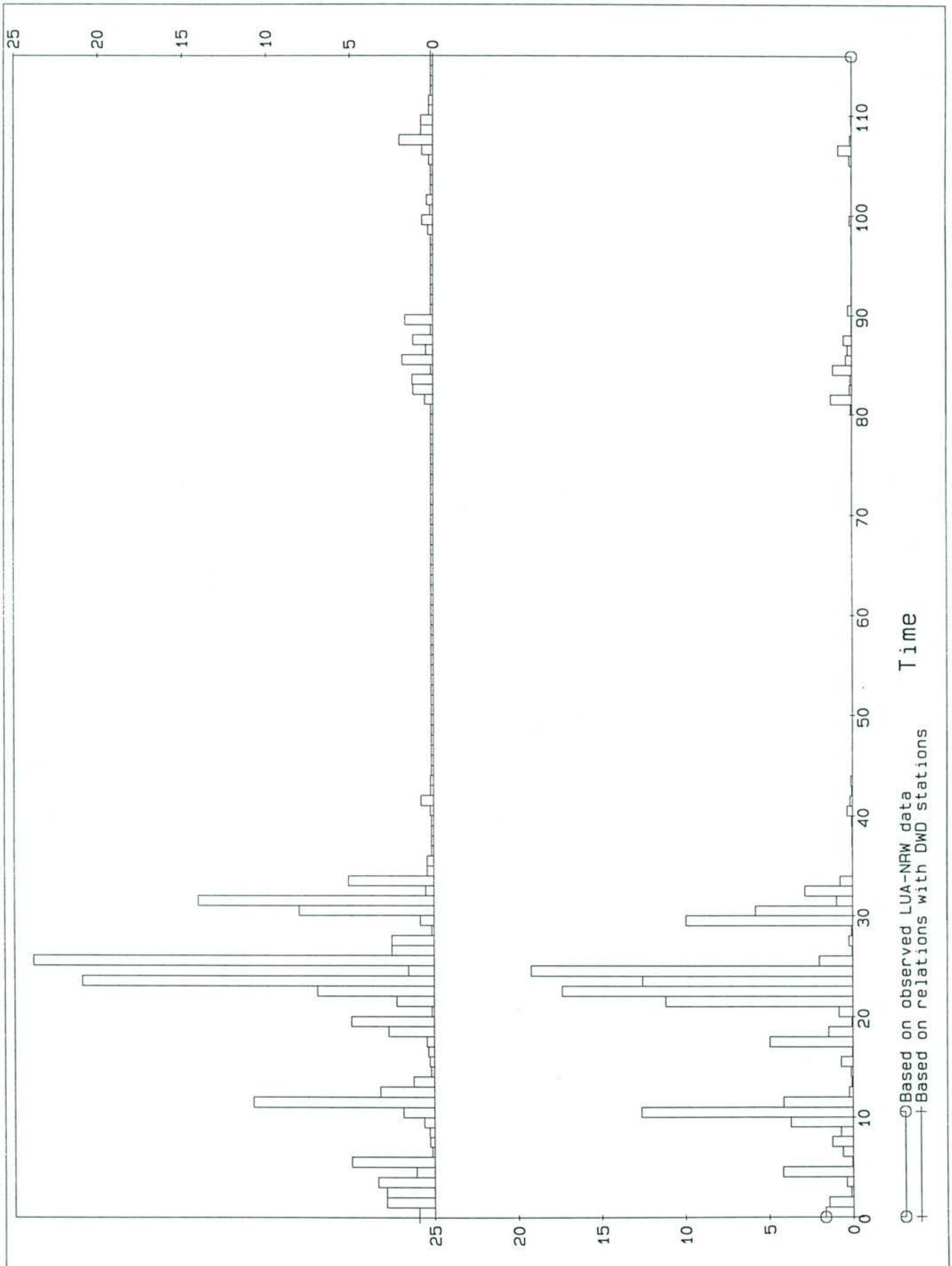
Fig. 10.8a Lippe Level 1: Results of rainfall sensitivity analysis for Period no. 9.



Notes:

1. Overestimation of forecasted rainfall refers to: +20% for 0<t<24, +40% for 24<t<48 hours, and +60% for 48<t<60 hours.
2. Underestimation of forecasted rainfall refers to: -20% for 0<t<24 and -40% for 24<t<48 hours; and -60% for 48<t<60 hours.

Fig. 10.8b Lippe Level 1: Results of rainfall sensitivity analysis for Period no. 9.



Sieg basin, Areal rainfall comparison.
Observed & computed (with established DWD relationships) areal rainfall.

Period no. 5

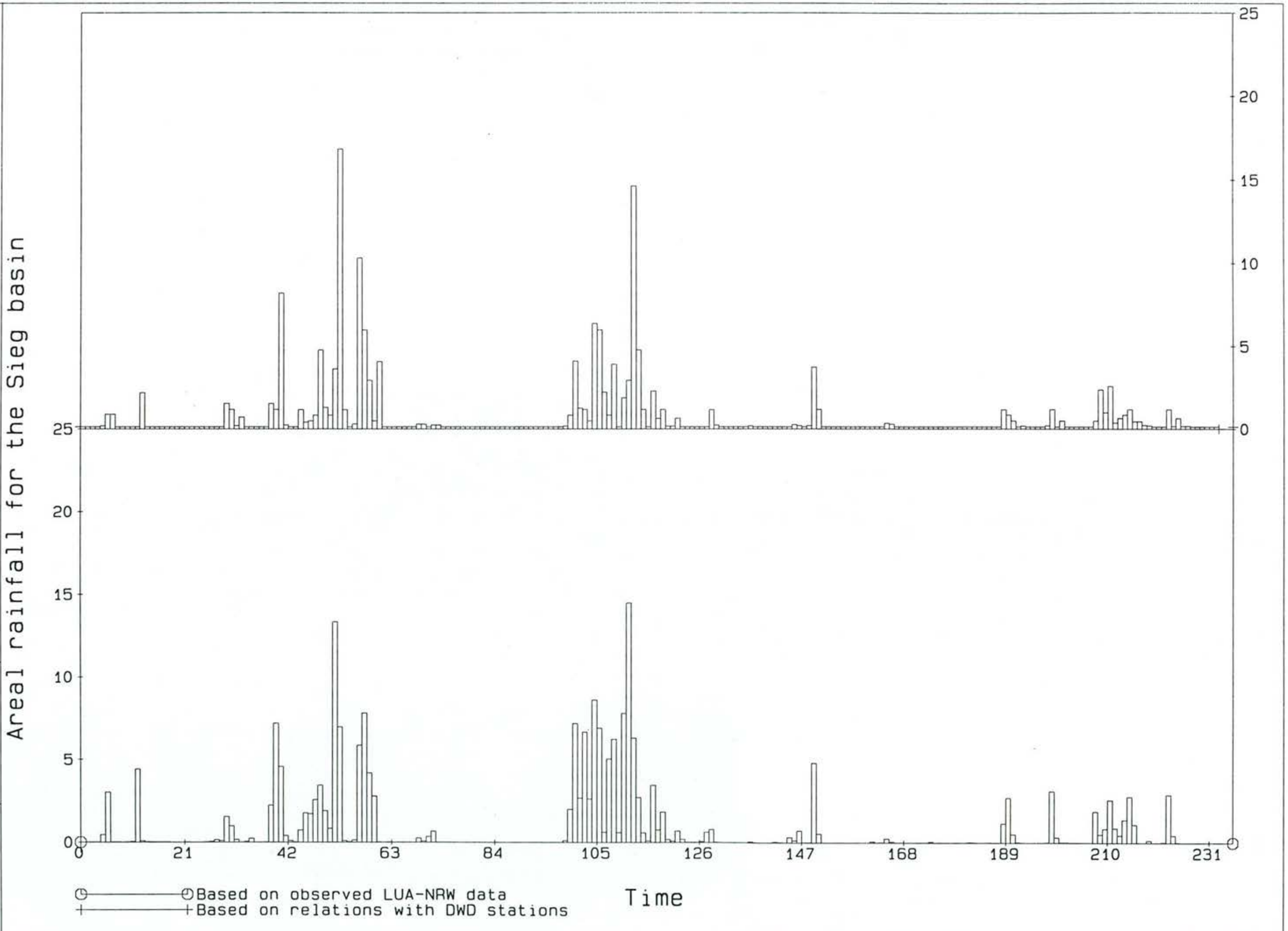
DELFT HYDRAULICS

R3049

Fig. 10.9

DELFT HYDRAULICS

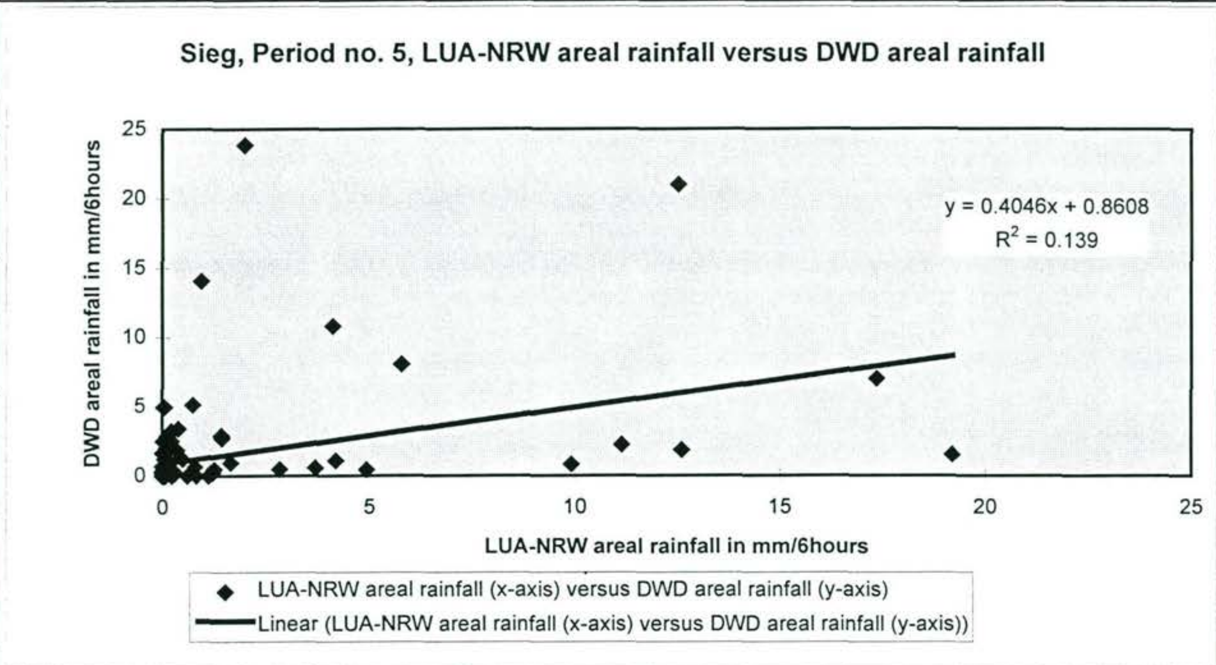
Sieg basin, Areal rainfall comparison.
Observed & computed (with established
DWD relationships) areal rainfall.



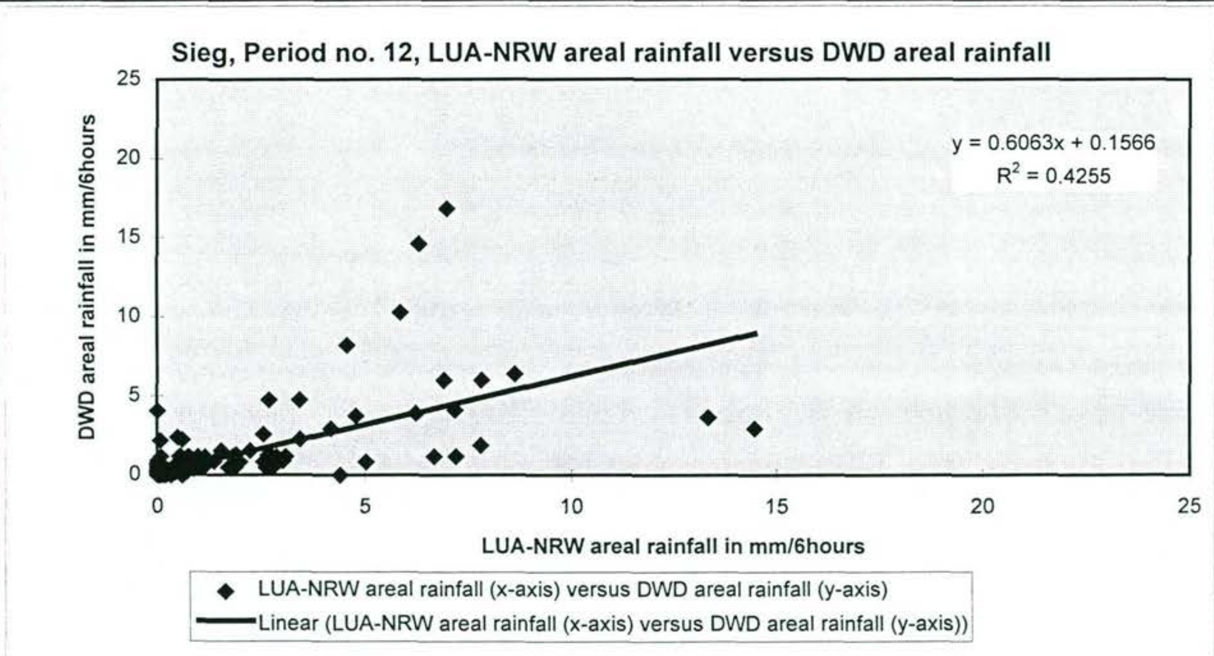
Period no. 12

R3049

Fig. 10.10

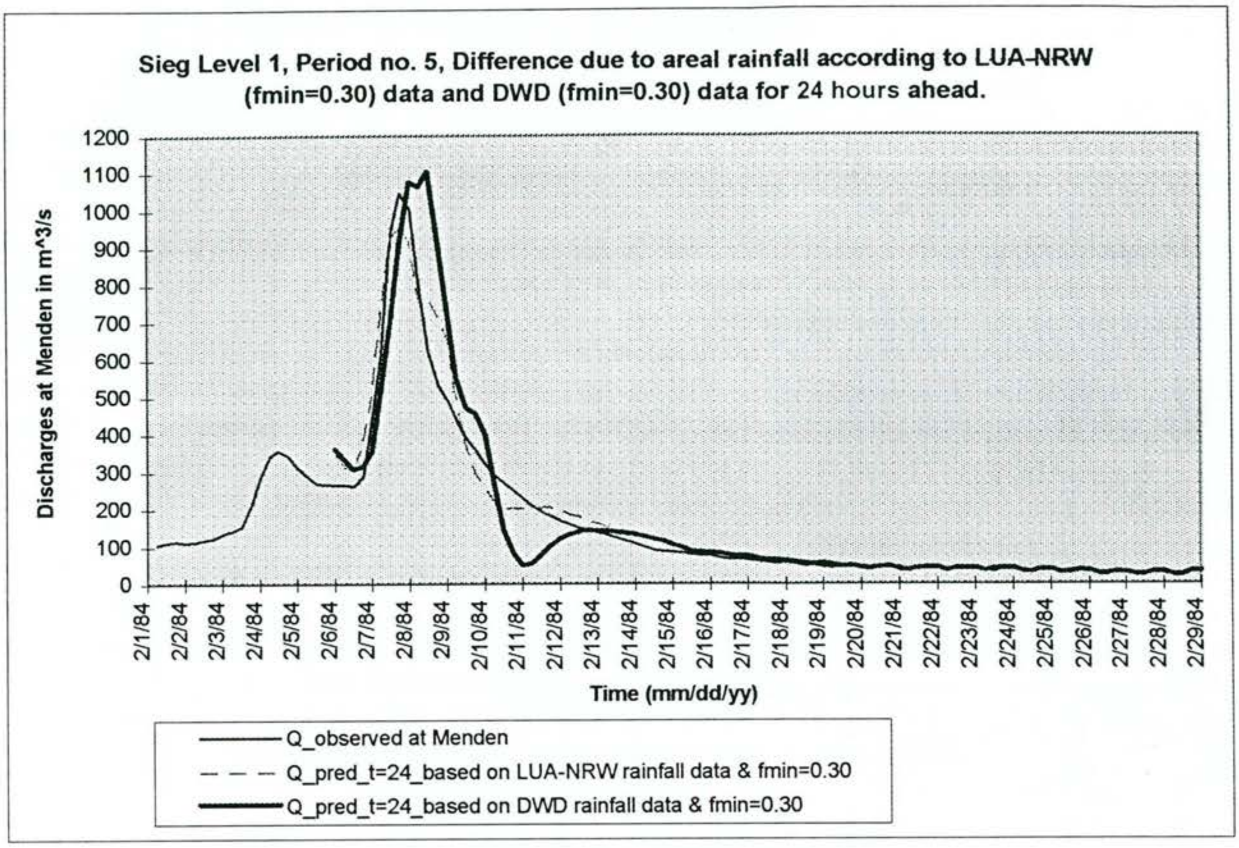


Period no. 5:		
Correlation coefficient between LUA-NRW & DWD areal rainfall	0.37	
Total volume of LUA-NRW areal rainfall	127.9	mm
Total volume of DWD areal rainfall	149.0	mm



Period no. 12:		
Correlation coefficient between LUA-NRW & DWD areal rainfall	0.65	
Total volume of LUA-NRW areal rainfall	201.8	mm
Total volume of DWD areal rainfall	158.8	mm

Fig. 10.11 Sieg, Period 5 & 12, Correlation between LUA-NRW and DWD areal rainfall.



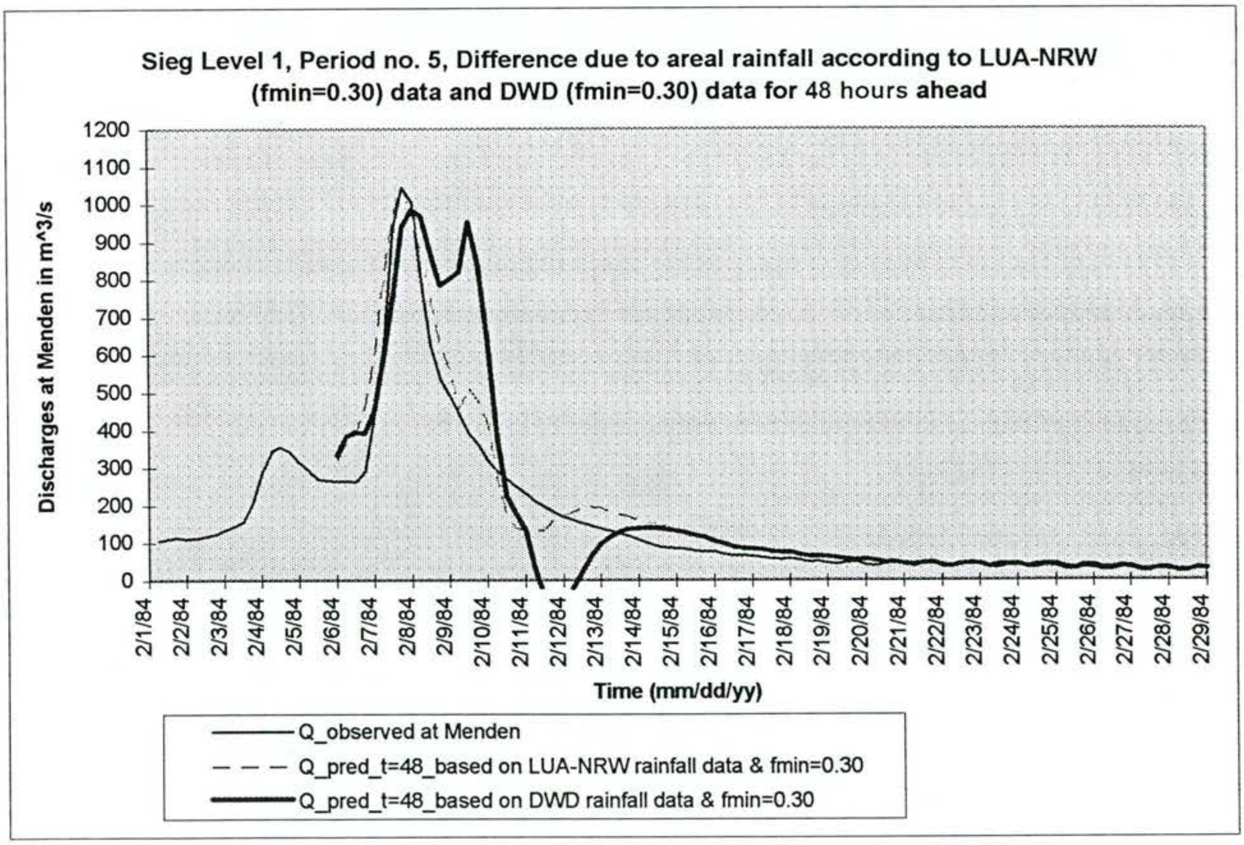
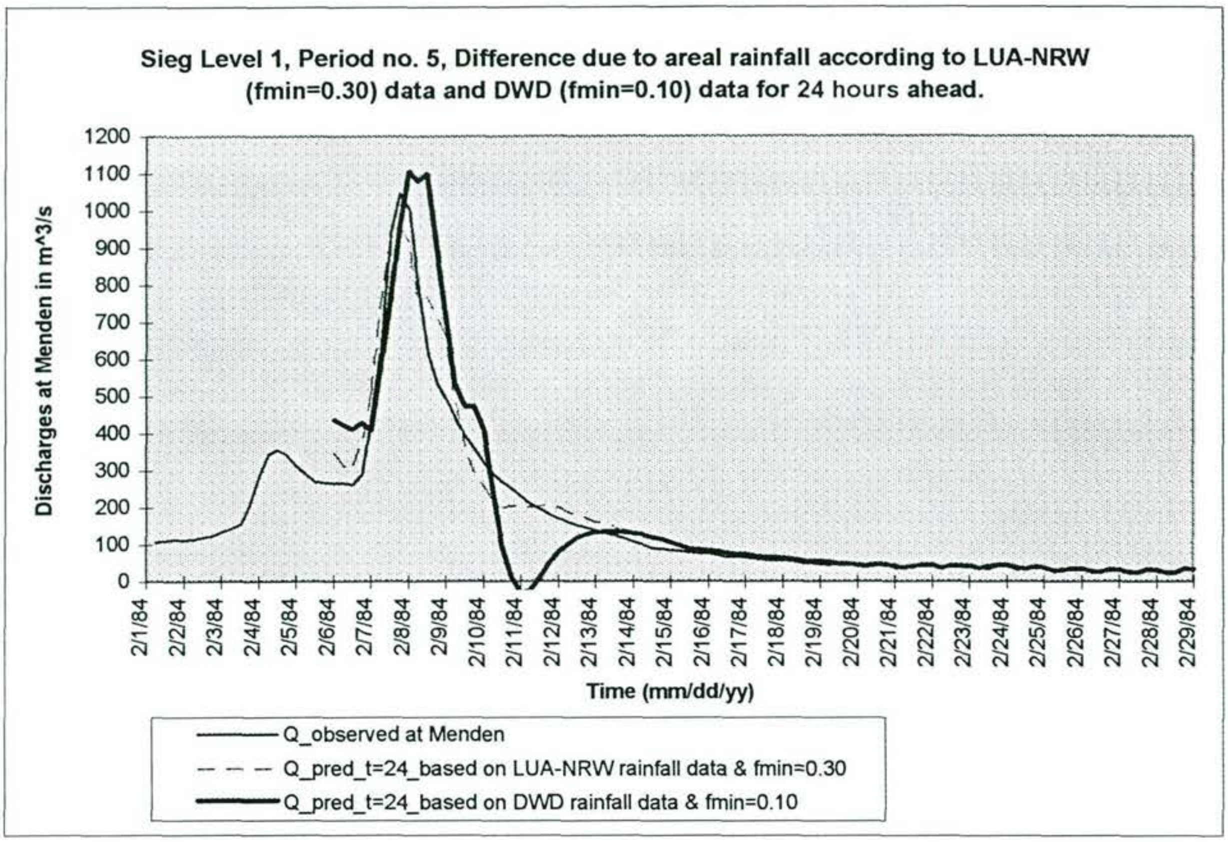


Fig. 10.12 Sieg Level 1, Period no. 5, Sensitivity to LUA-NRW and DWD areal rainfall, in both computations **fmin=0.30** was used.



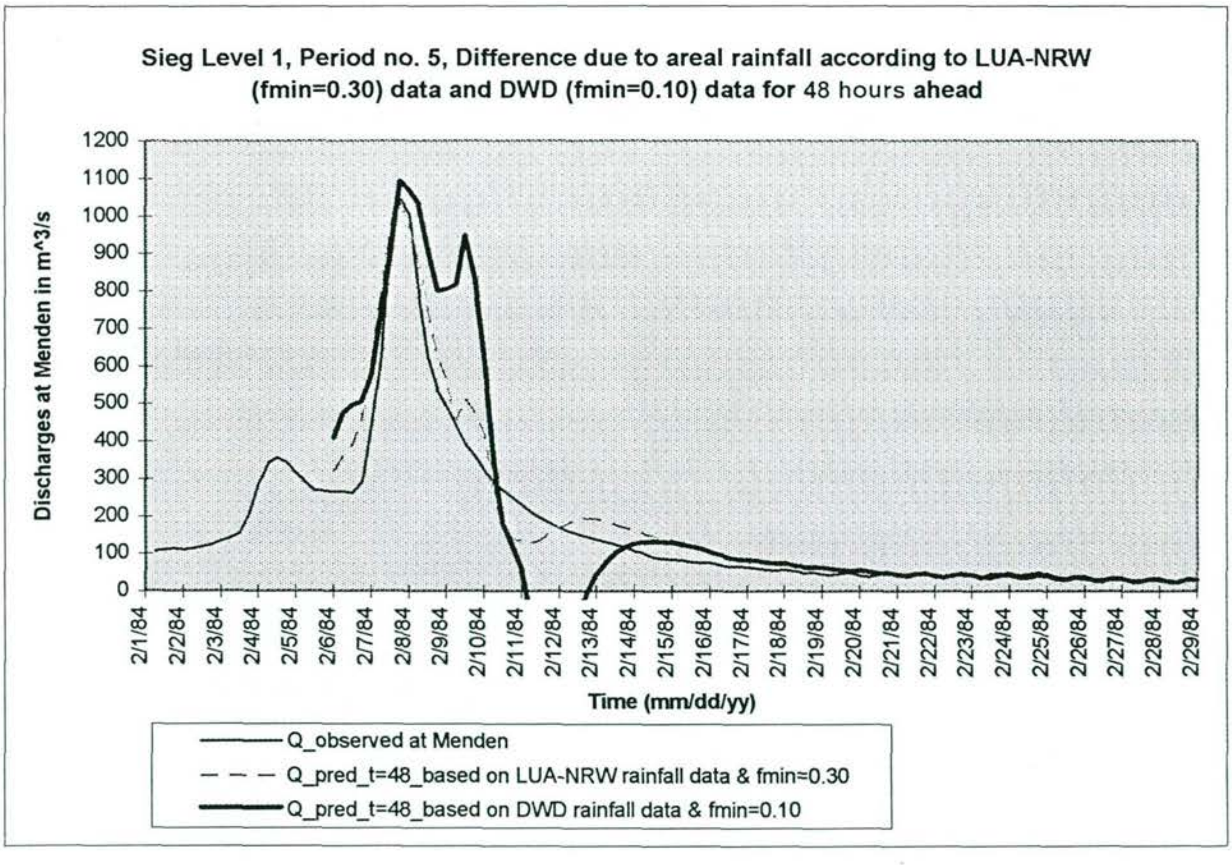
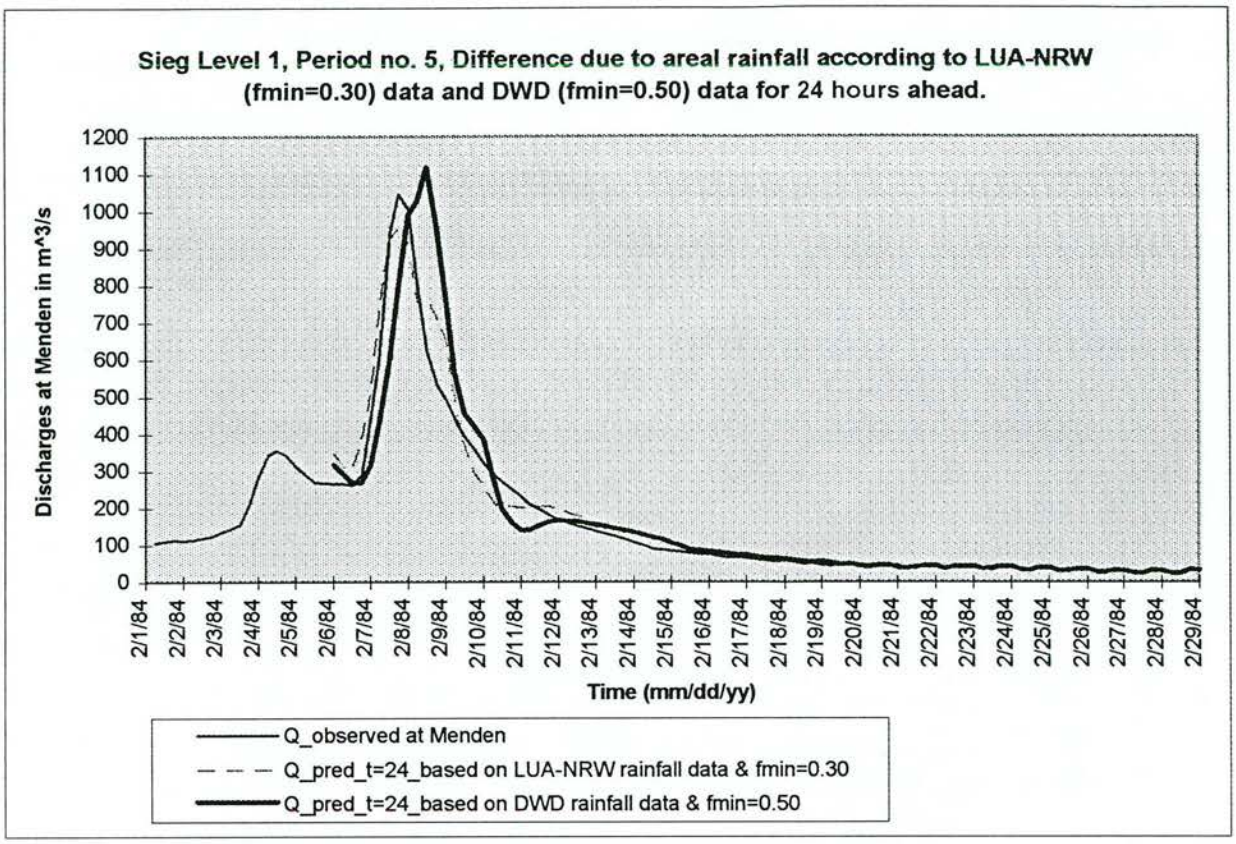


Fig. 10.13 Sieg Level 1, Period no. 5, Sensitivity to LUA-NRW and DWD areal rainfall, **fmin=0.30** for LUA-NRW & **fmin = 0.10** for DWD.



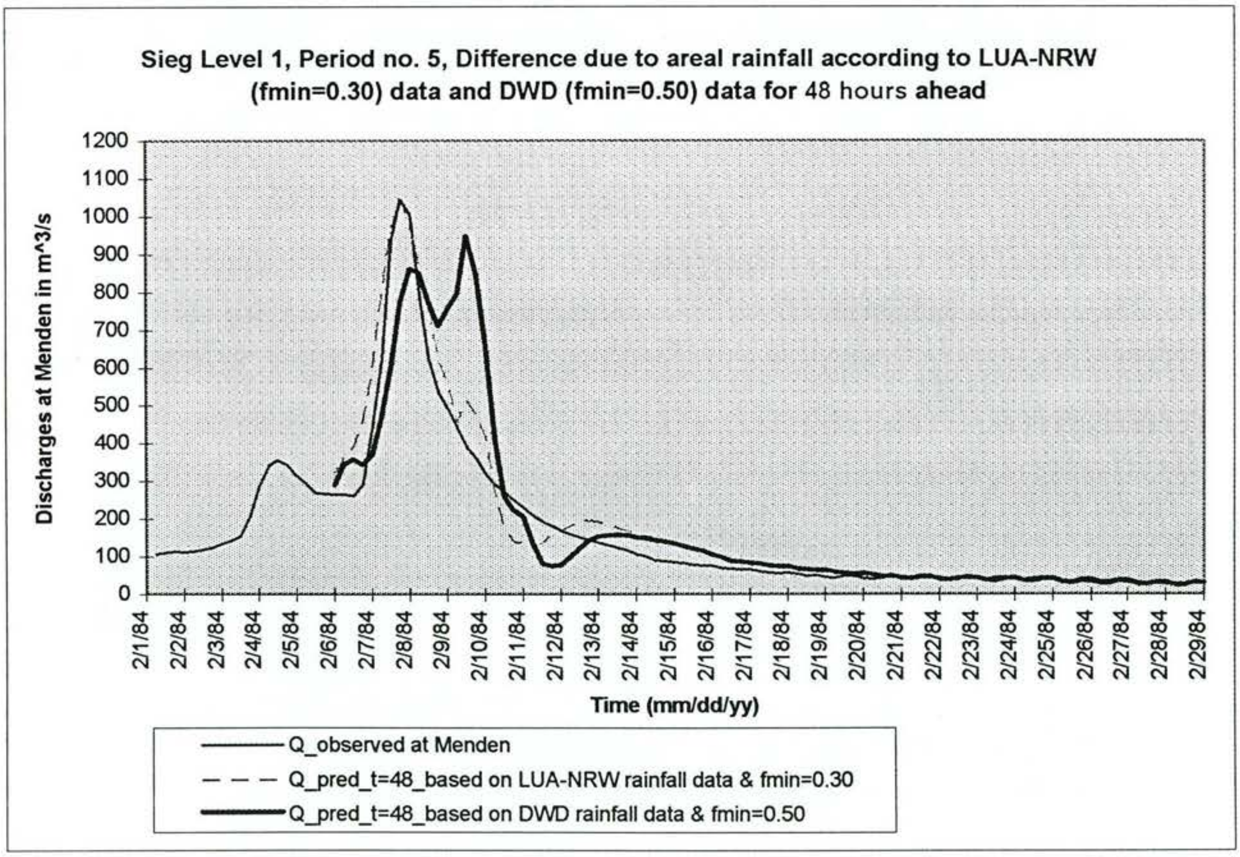
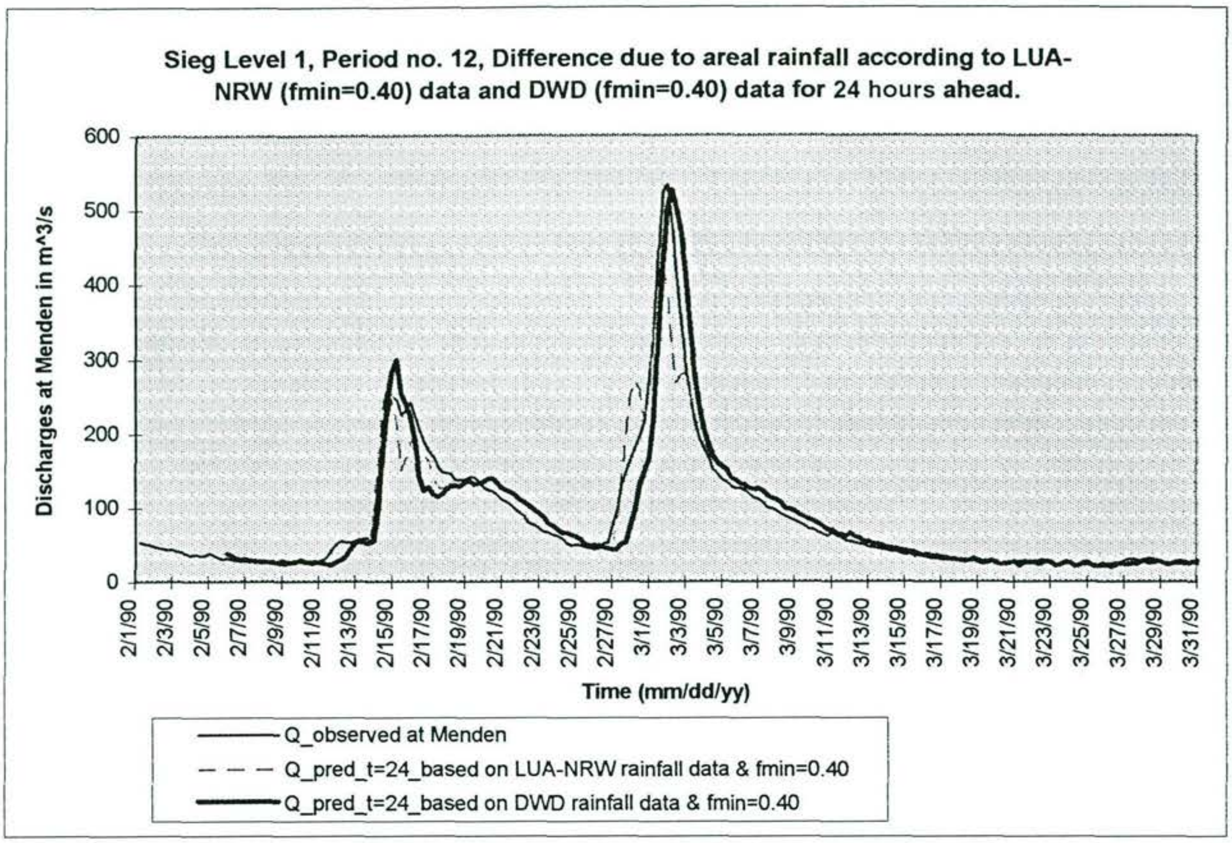


Fig. 10.14 Sieg Level 1, Period no. 5, Sensitivity to LUA-NRW and DWD areal rainfall, **fmin=0.30** for LUA-NRW & **fmin = 0.50** for DWD.



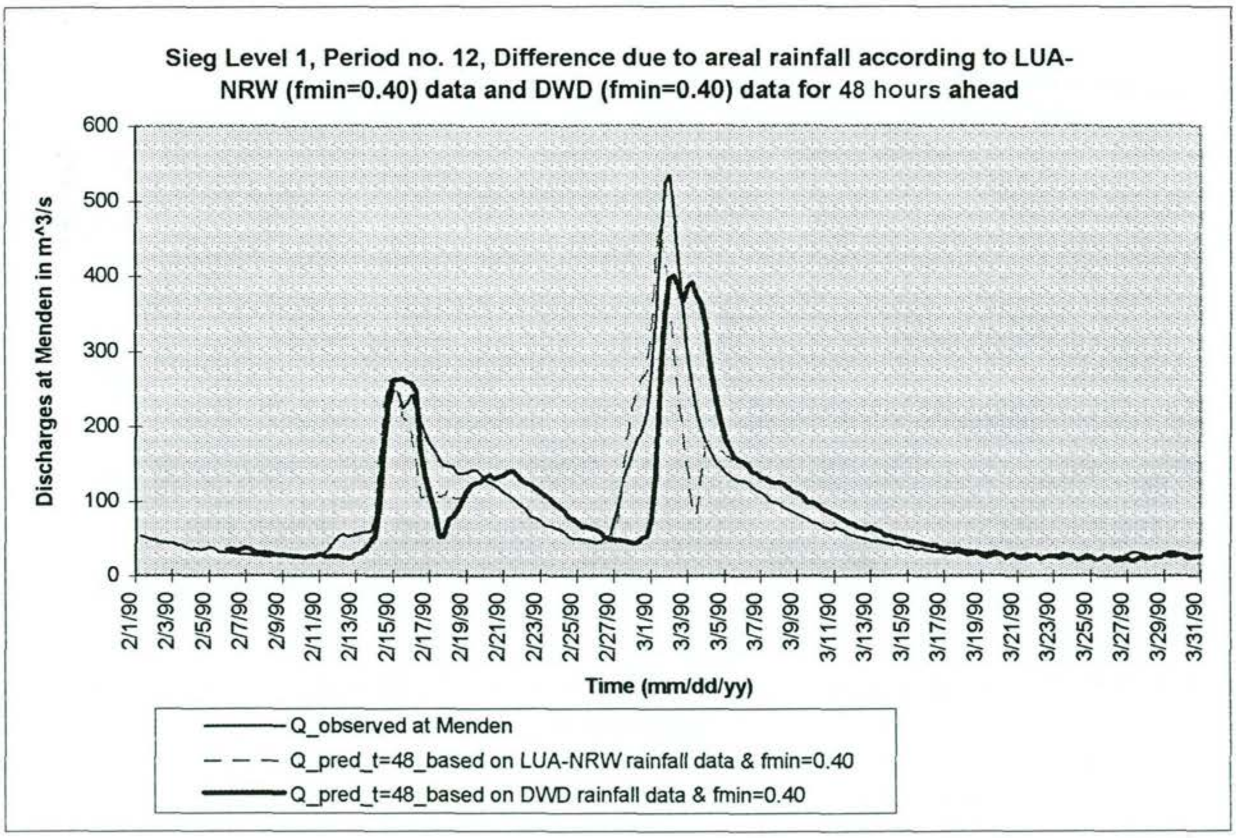
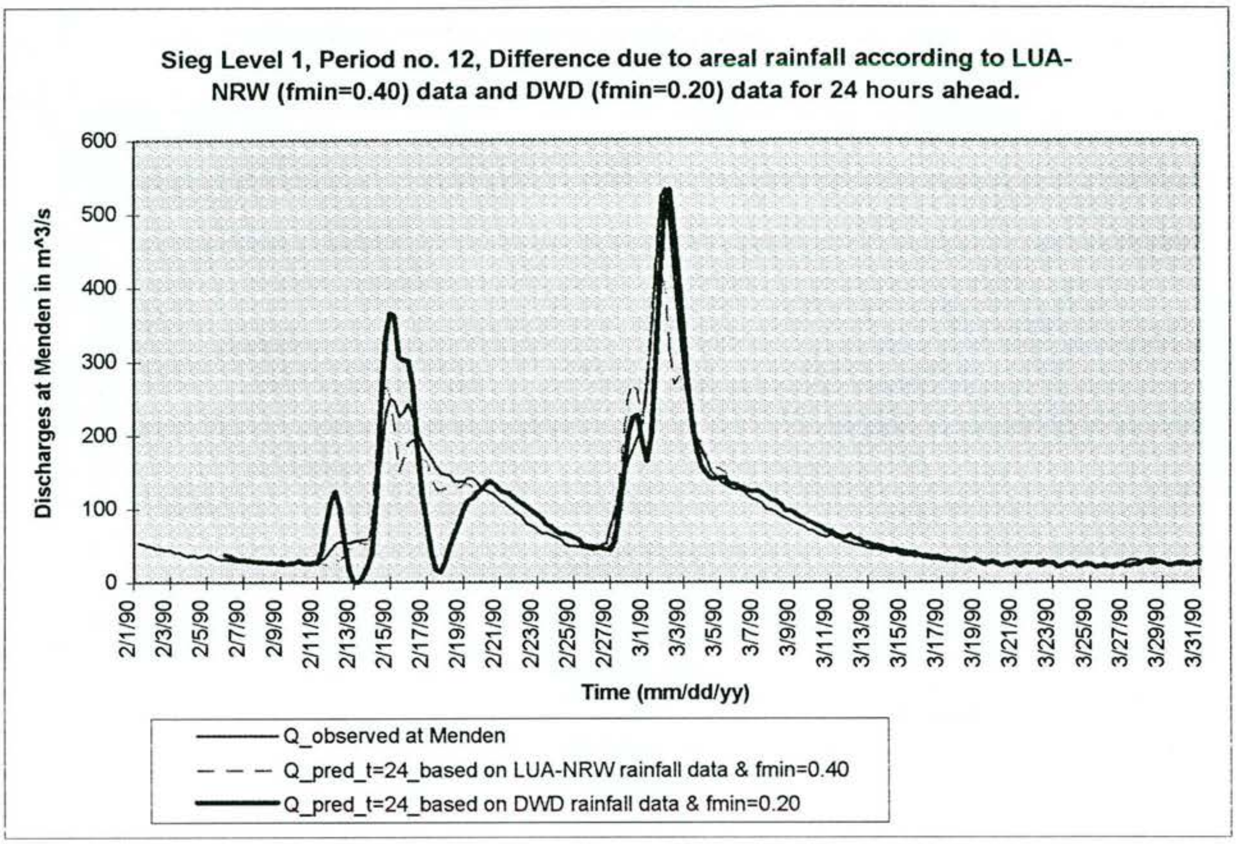


Fig. 10.15 Sieg Level 1, Period no. 12, Sensitivity to LUA-NRW and DWD areal rainfall, in both computations **fmin=0.40** was used.



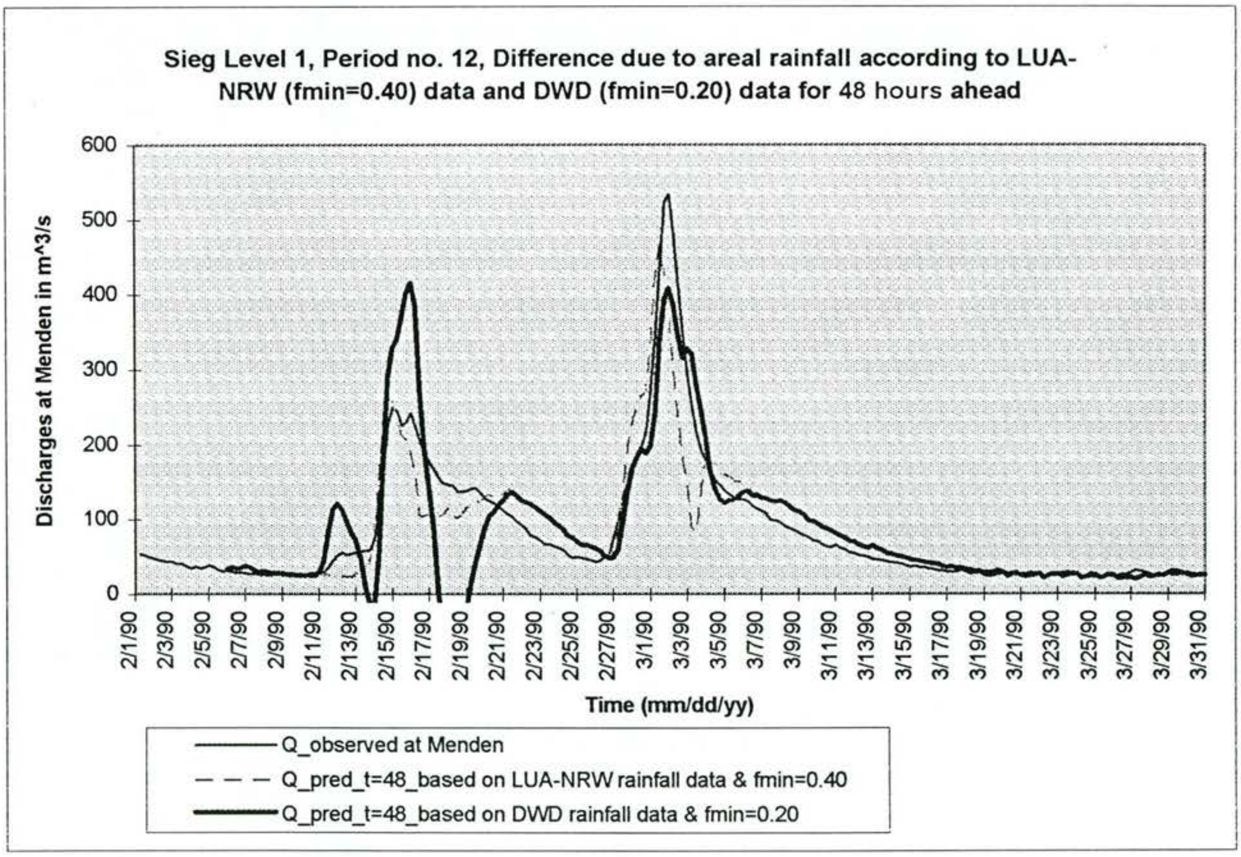
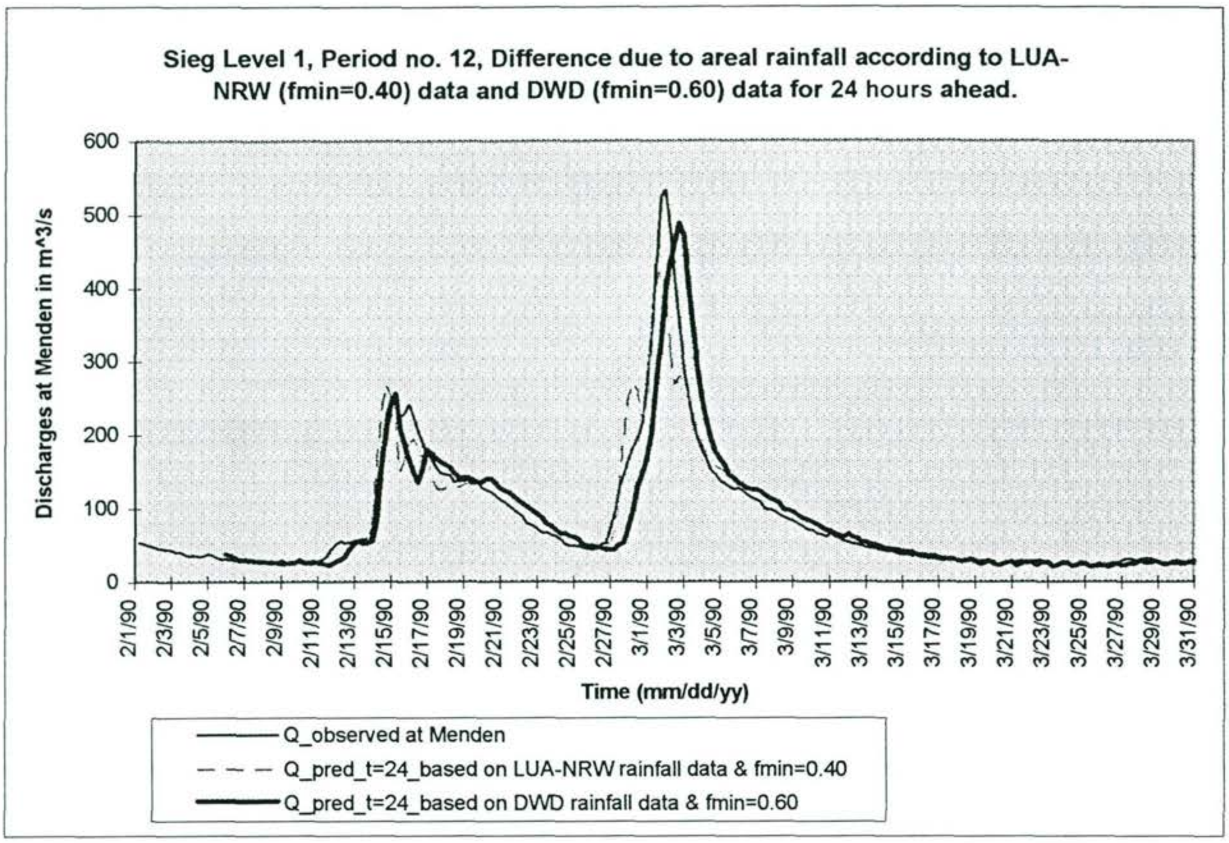


Fig. 10.16 Sieg Level 1, Period no. 12, Sensitivity to LUA-NRW and DWD areal rainfall, **fmin=0.40** for LUA-NRW & **fmin = 0.20** for DWD.



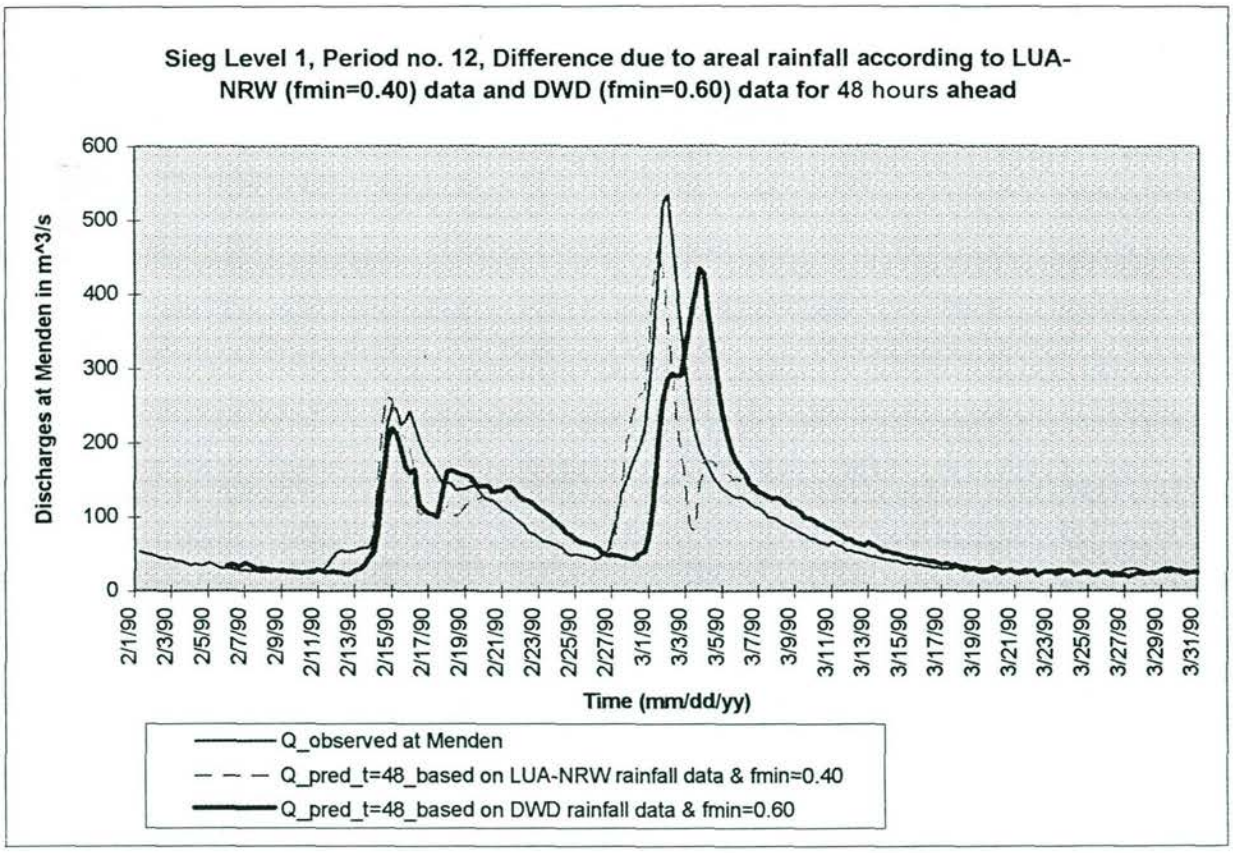
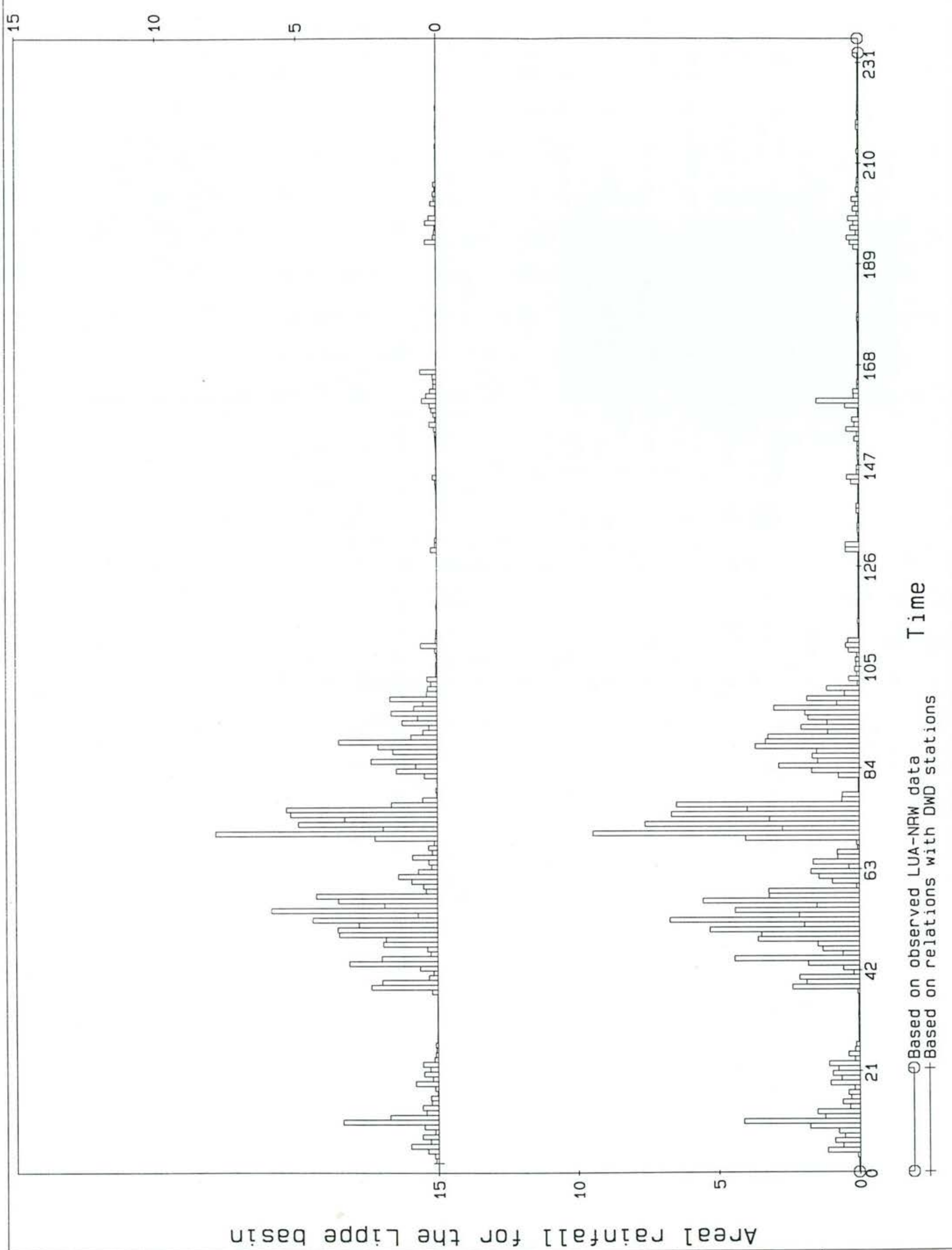


Fig. 10.17 Sieg Level 1, Period no. 12, Sensitivity to LUA-NRW and DWD areal rainfall, **fmin=0.40** for LUA-NRW & **fmin = 0.60** for DWD.



Lippe basin, Areal rainfall comparison Observed & computed (with established DWD relationships) areal rainfall	Period no. 7
DELFT HYDRAULICS	R3049 **Fig. 10.18**

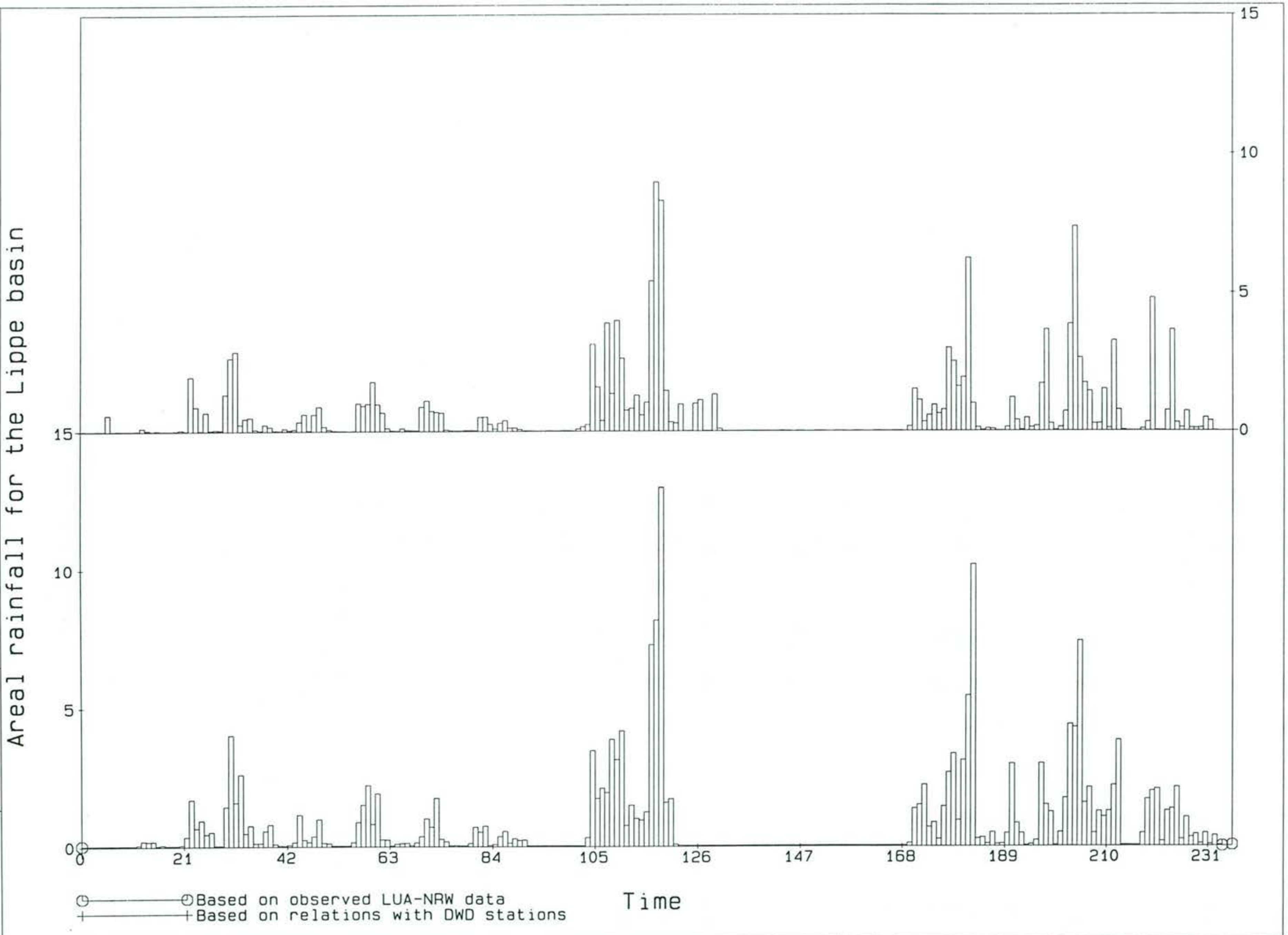
DELFT HYDRAULICS

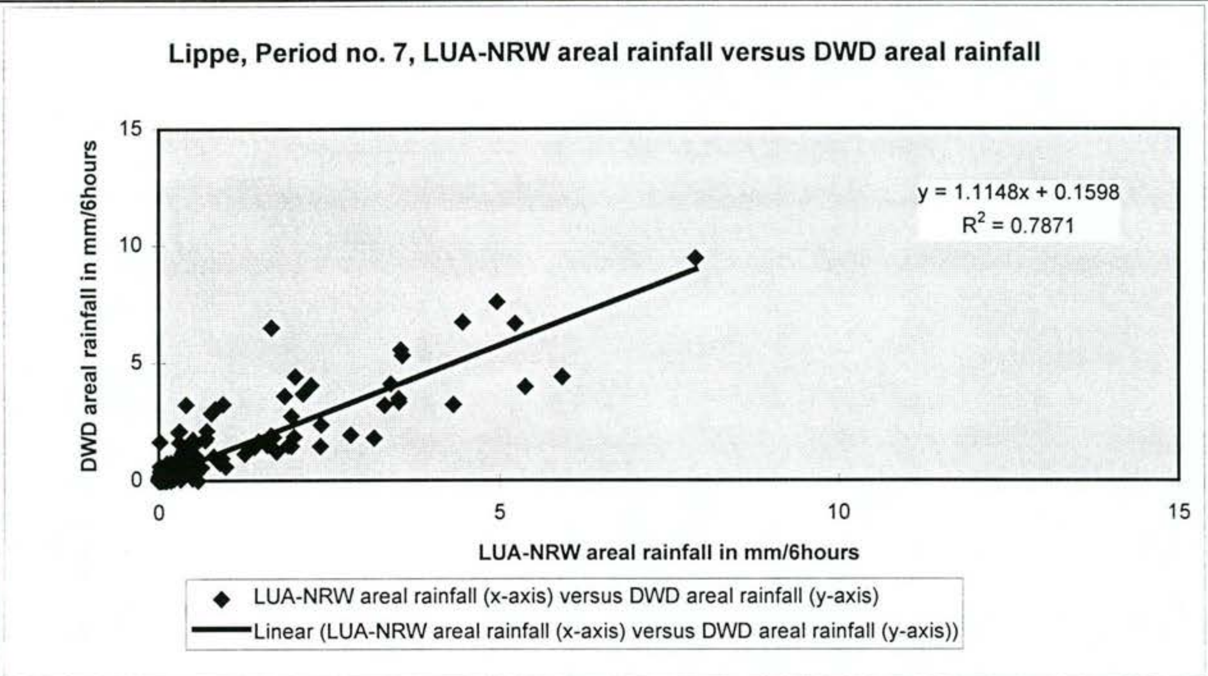
Lippe basin, Areal rainfall comparison
Observed & computed (with established
DWD relationships) areal rainfall

R3049

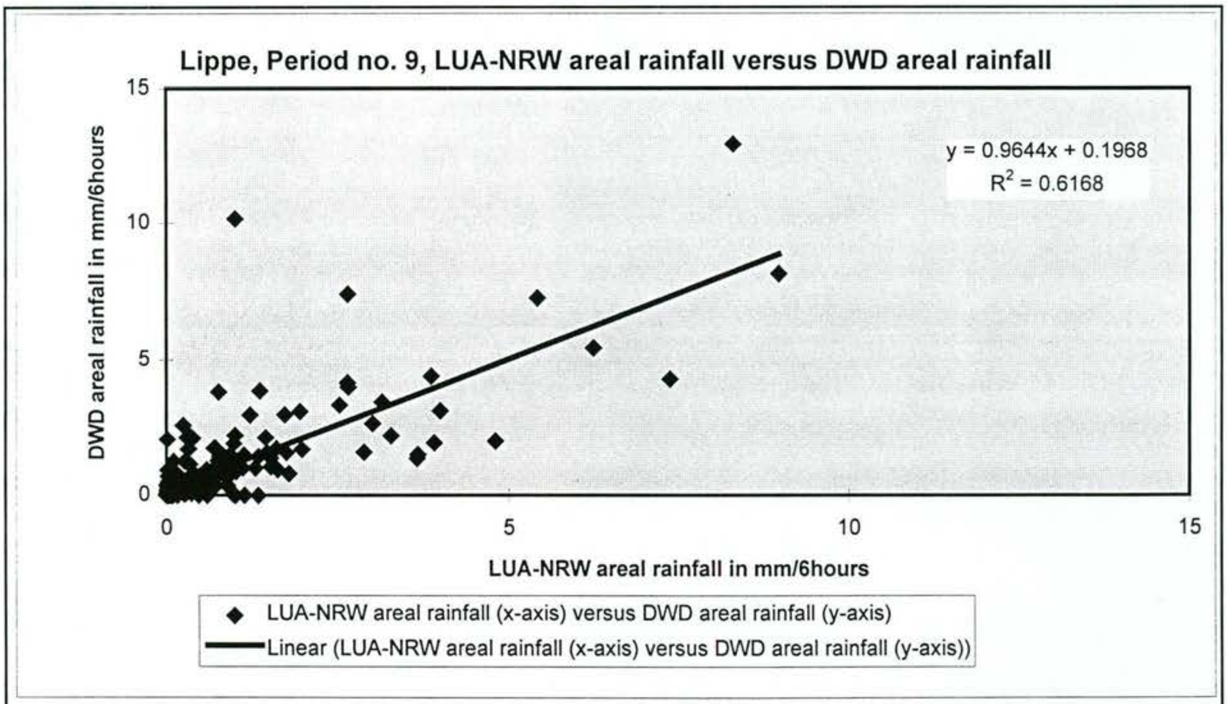
Period no. 9

Fig. 10.19



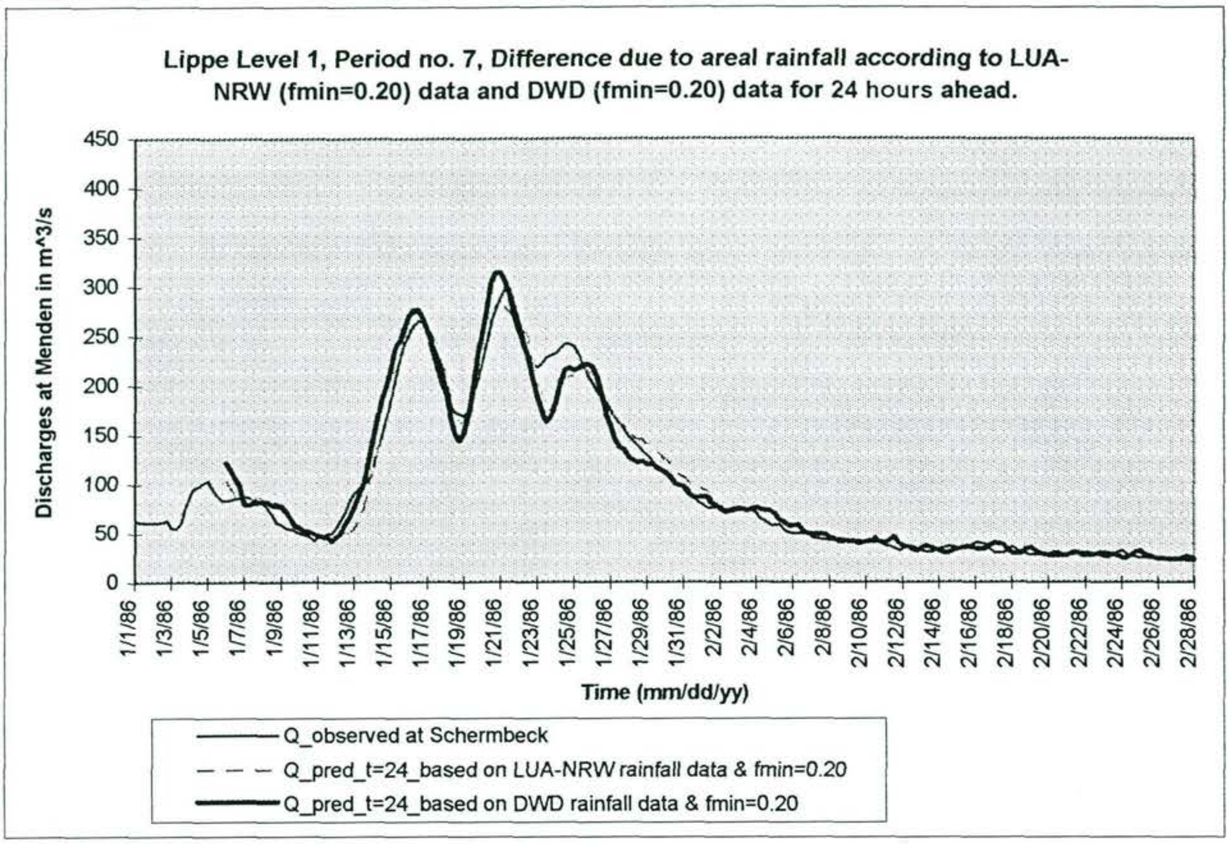


Period no. 7:		
Correlation coefficient between LUA-NRW & DWD areal rainfall	0.89	
Total volume of LUA-NRW areal rainfall	126.0	mm
Total volume of DWD areal rainfall	177.7	mm



Period no. 9:		
Correlation coefficient between LUA-NRW & DWD areal rainfall	0.79	
Total volume of LUA-NRW areal rainfall	148.0	mm
Total volume of DWD areal rainfall	188.6	mm

Fig. 10.20 Lippe, Period 7 & 9, Correlation between LUA-NRW and DWD areal rainfall.



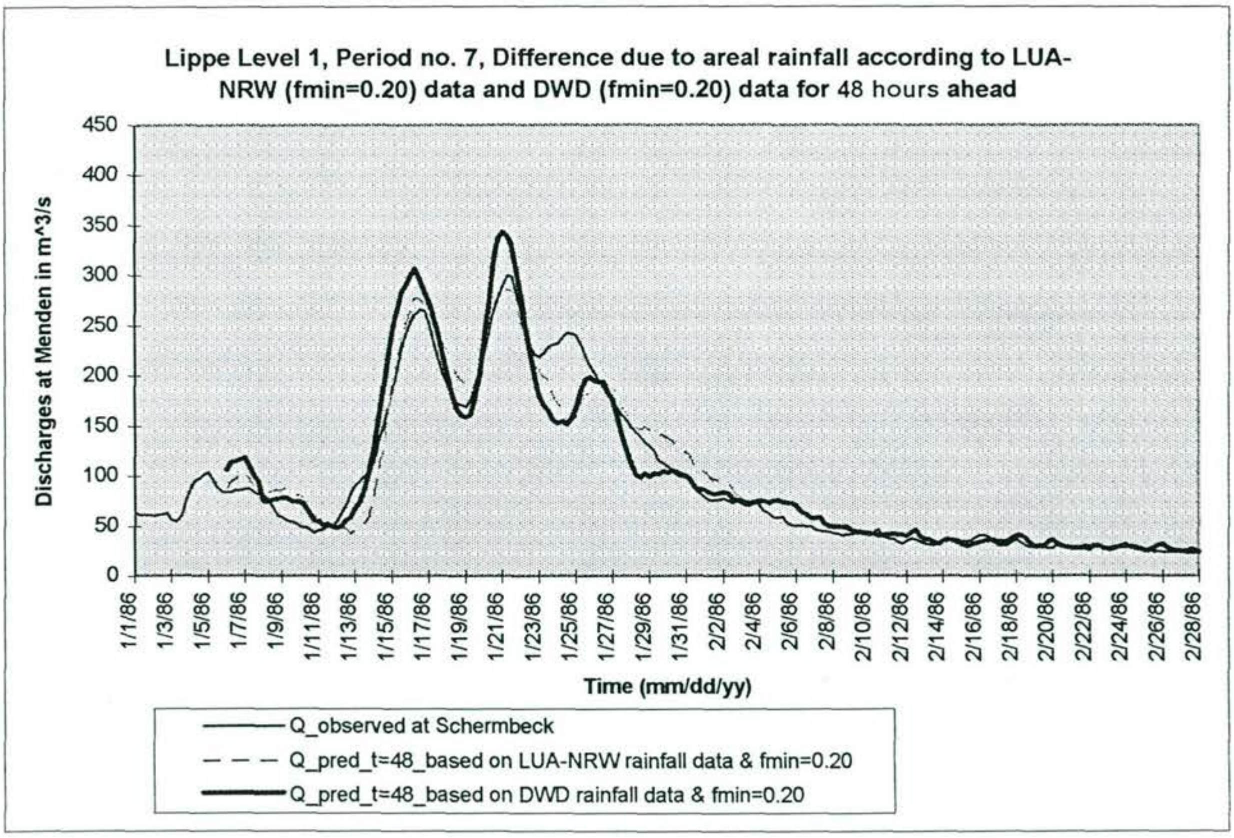


Fig. 10.21a Lippe Level 1, Period no. 7, Sensitivity to LUA-NRW and DWD areal rainfall, in both computations **fmin=0.20** was used.

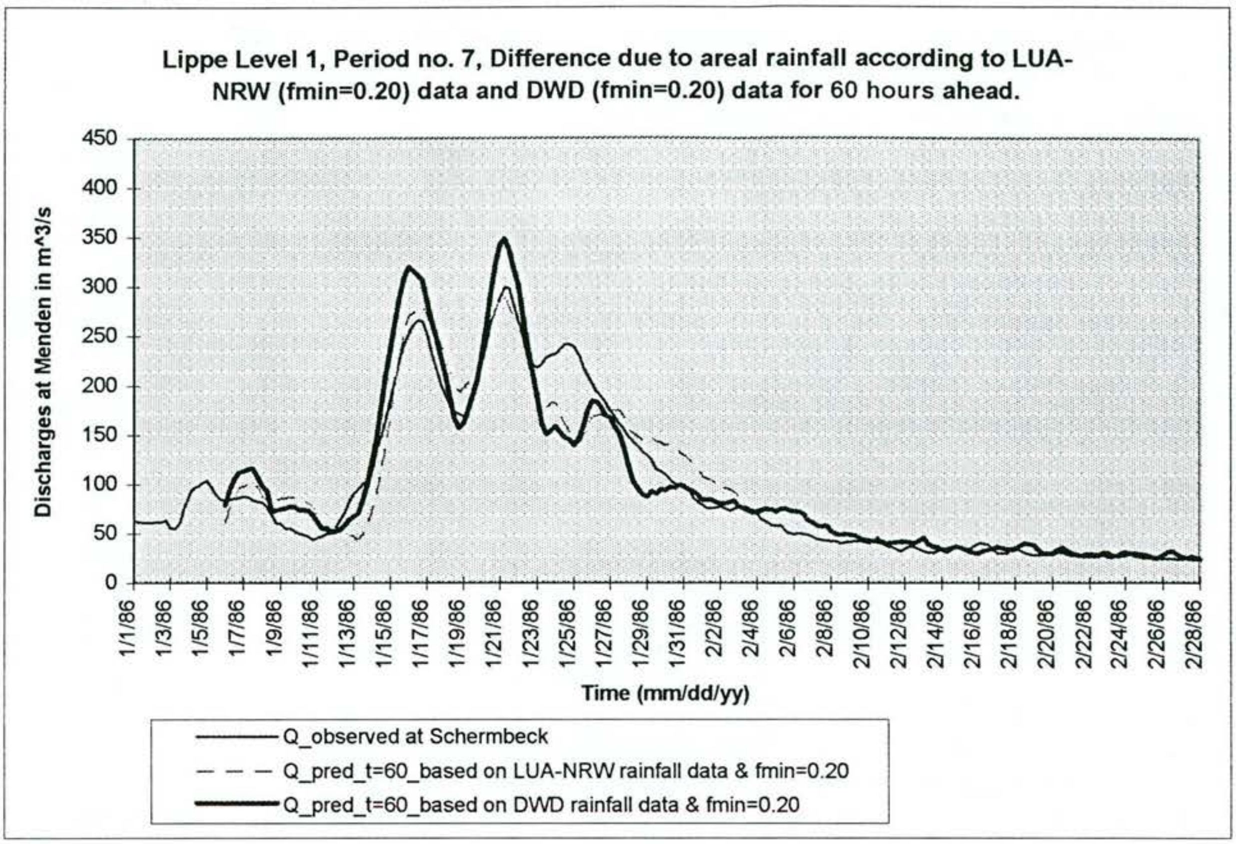
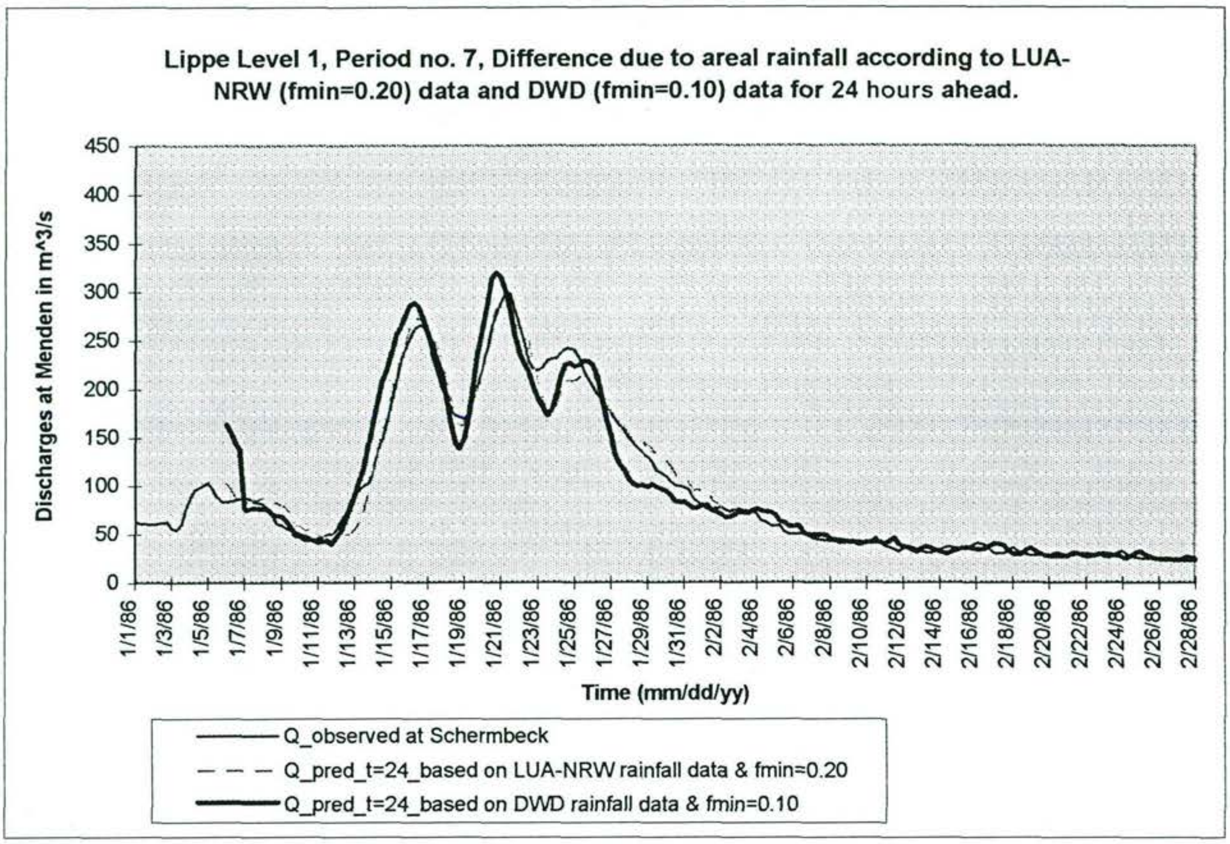


Fig. 10.21b Lippe Level 1, Period no. 7, Sensitivity to LUA-NRW and DWD areal rainfall, in both computations **fmin=0.20** was used.



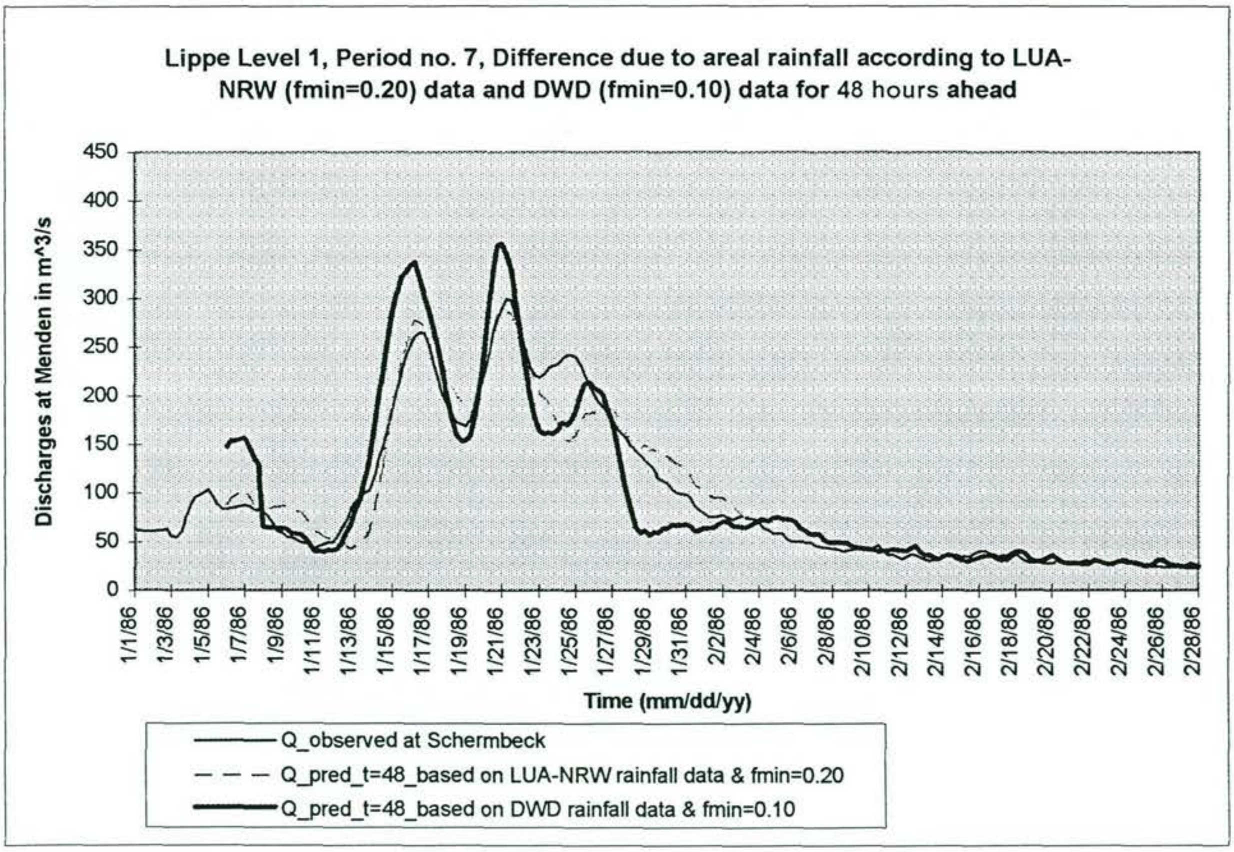


Fig. 10.22a Lippe Level 1, Period no. 7, Sensitivity to LUA-NRW and DWD areal rainfall, **fmin=0.20** for LUA-NRW & **fmin = 0.10** for DWD.

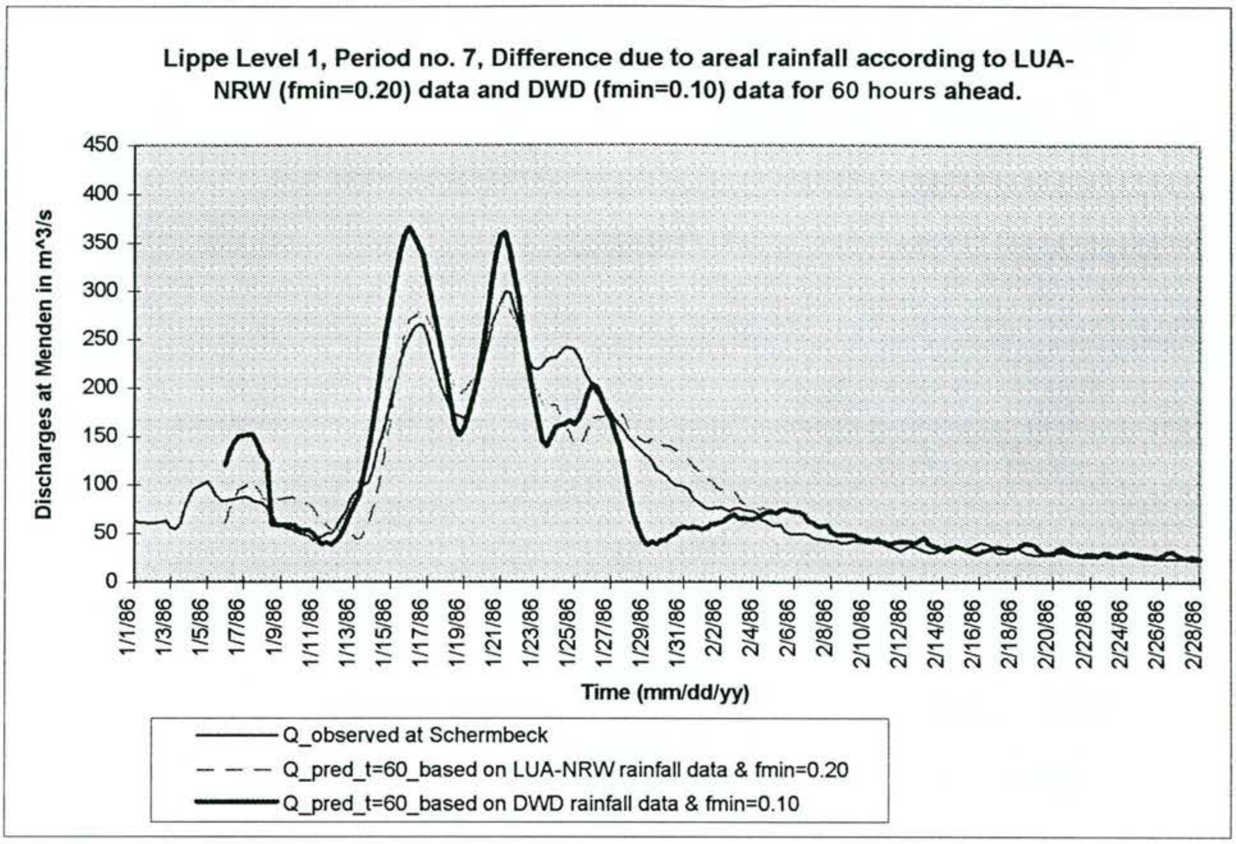
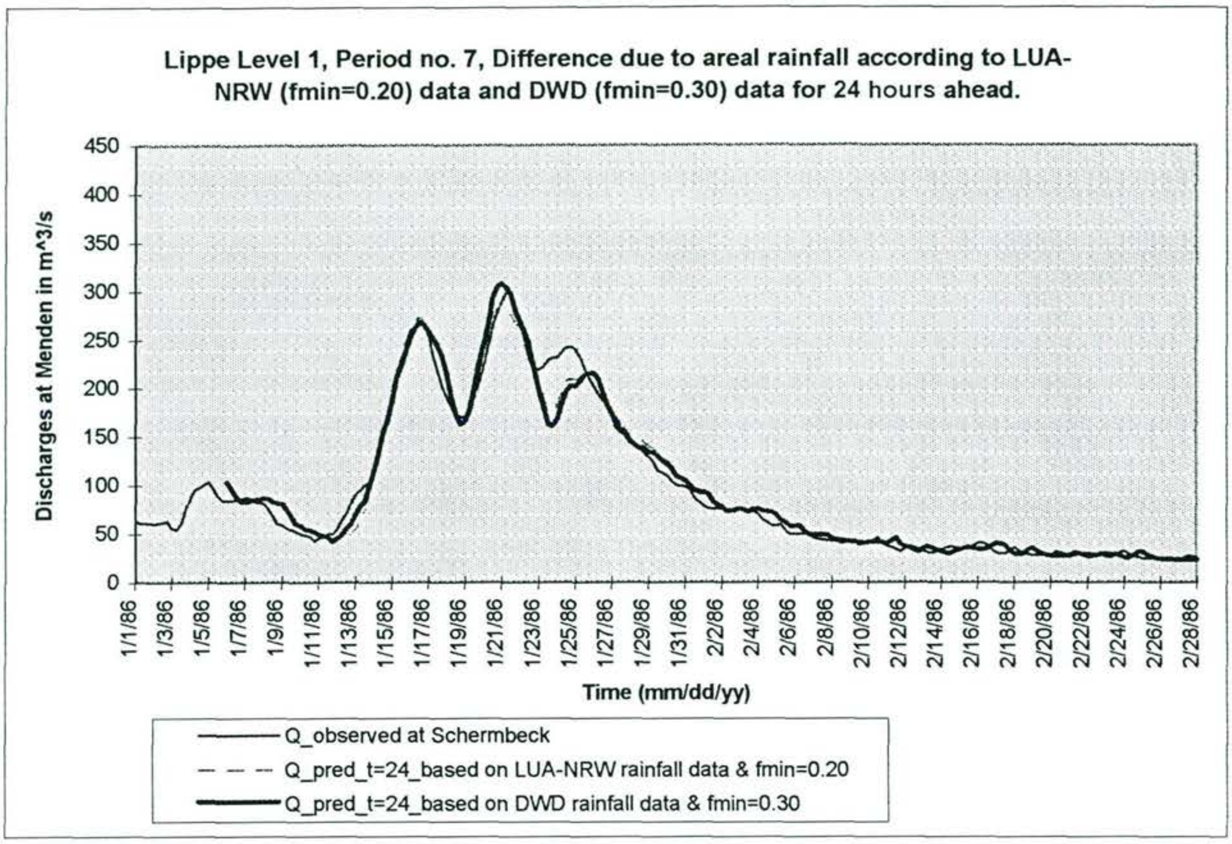


Fig. 10.22b Lippe Level 1, Period no. 7, Sensitivity to LUA-NRW and DWD areal rainfall, **fmin=0.20** for LUA-NRW & **fmin = 0.10** for DWD.



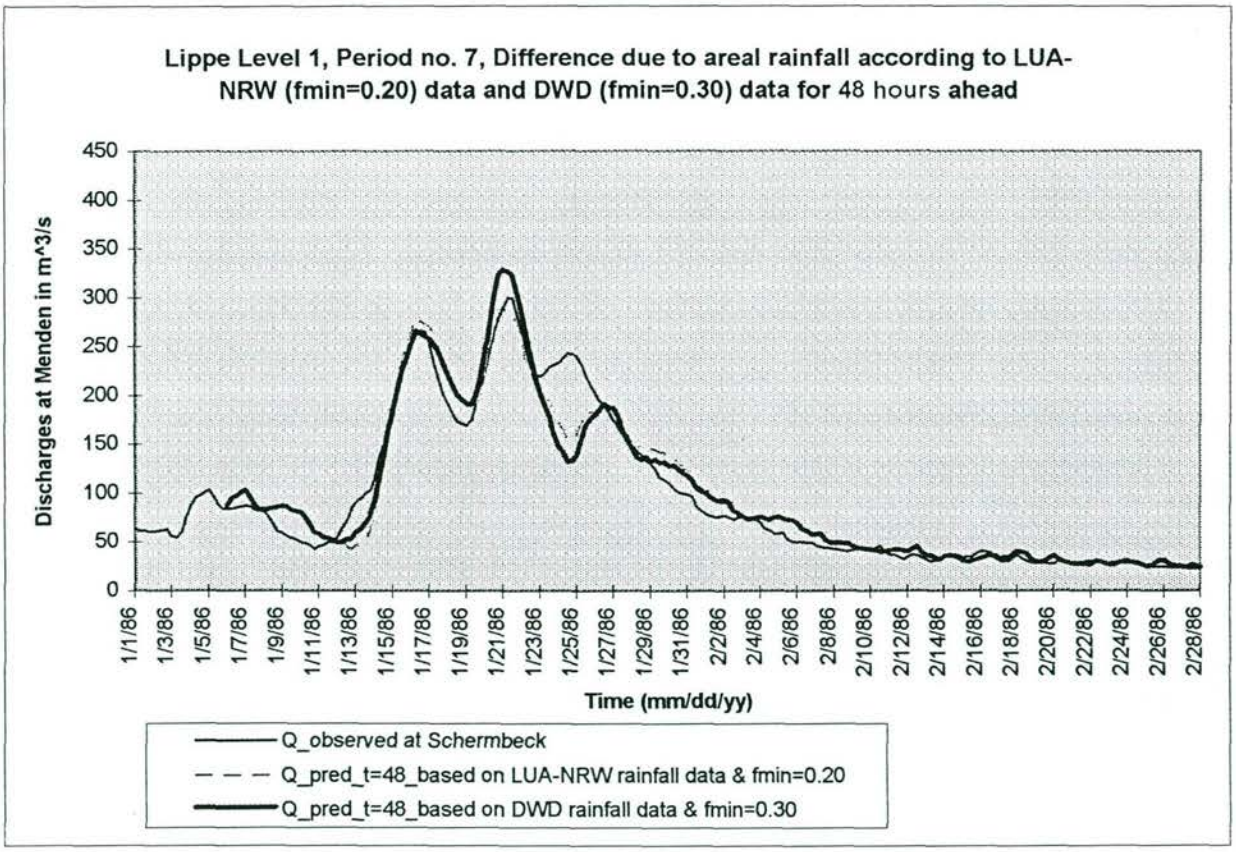


Fig. 10.23a Lippe Level 1, Period no. 7, Sensitivity to LUA-NRW and DWD areal rainfall, **fmin=0.20** for LUA-NRW & **fmin = 0.30** for DWD.

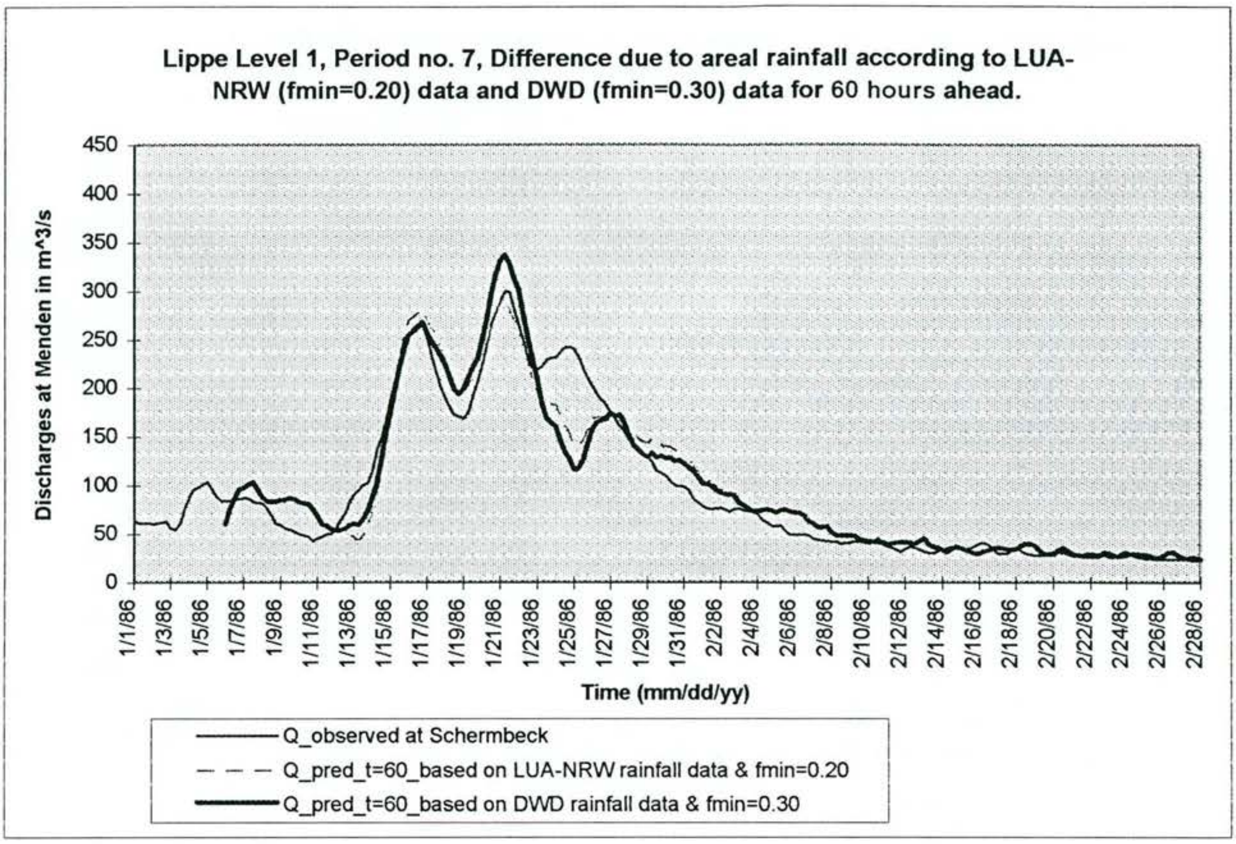
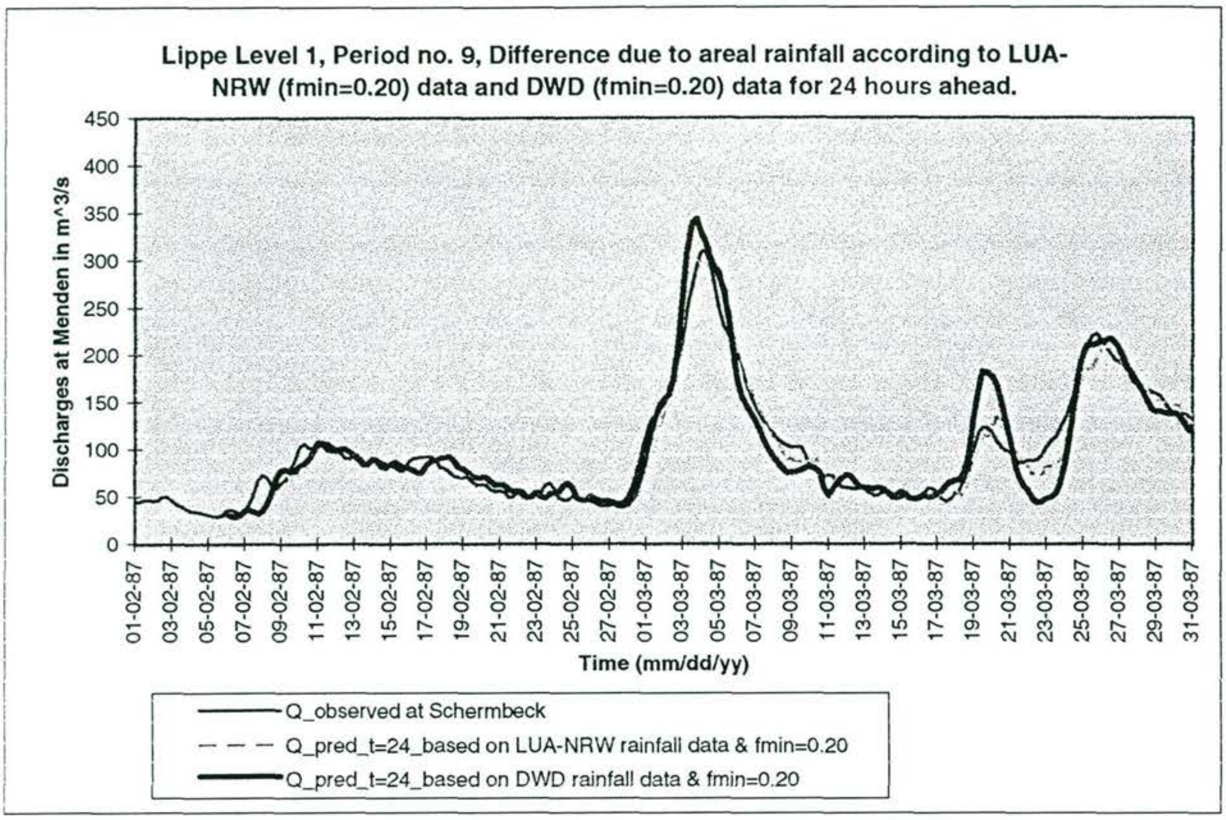


Fig. 10.23b Lippe Level 1. Period no. 7. Sensitivity to LUA-NRW and DWD areal rainfall. **fmin=0.20** for LUA-NRW & **fmin = 0.30** for DWD.



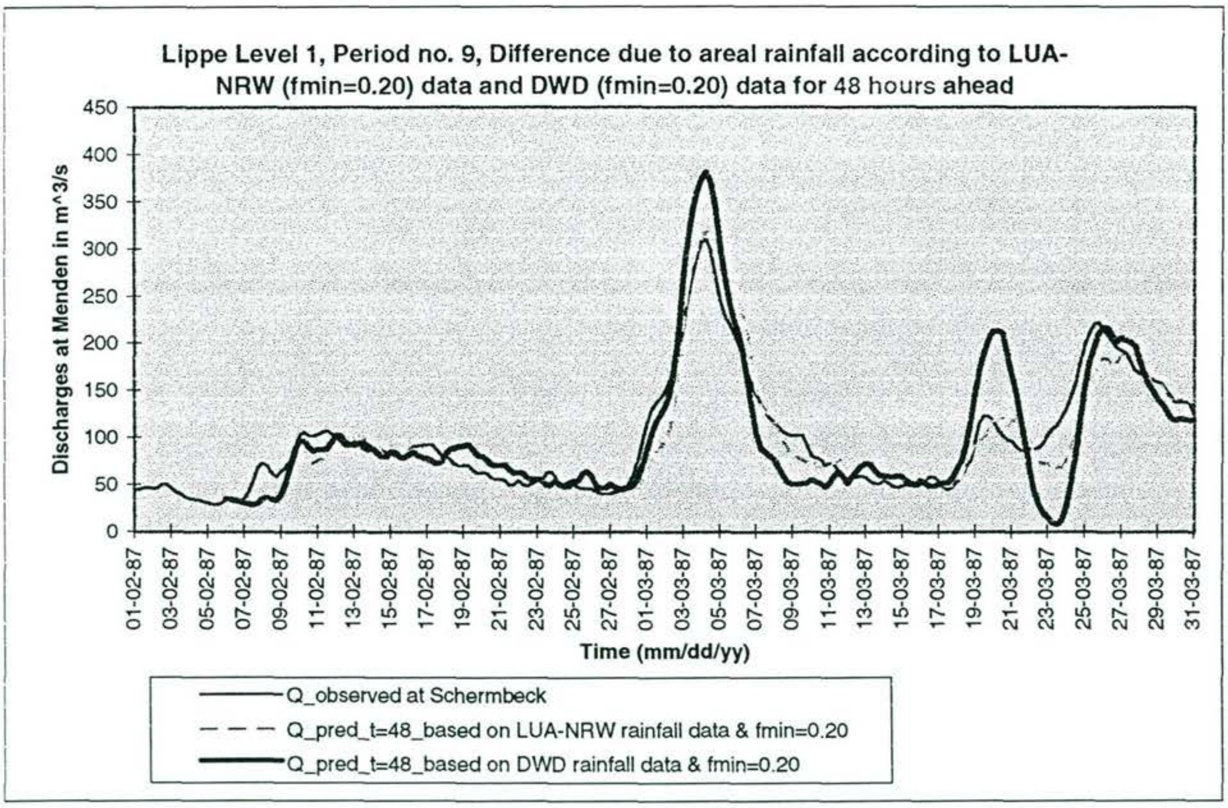


Fig. 10.24a Lippe Level 1, Period no. 9, Sensitivity to LUA-NRW and DWD areal rainfall, in both computations **fmin=0.20** was used.

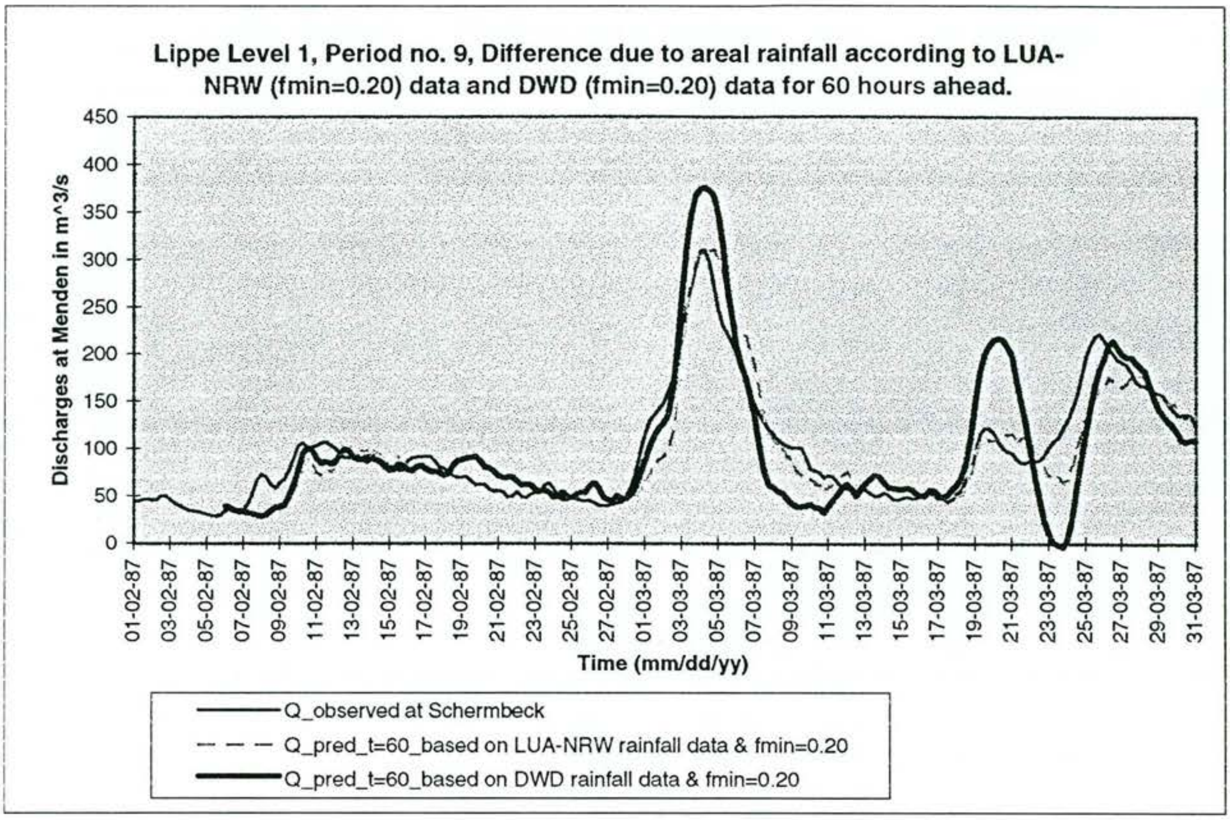
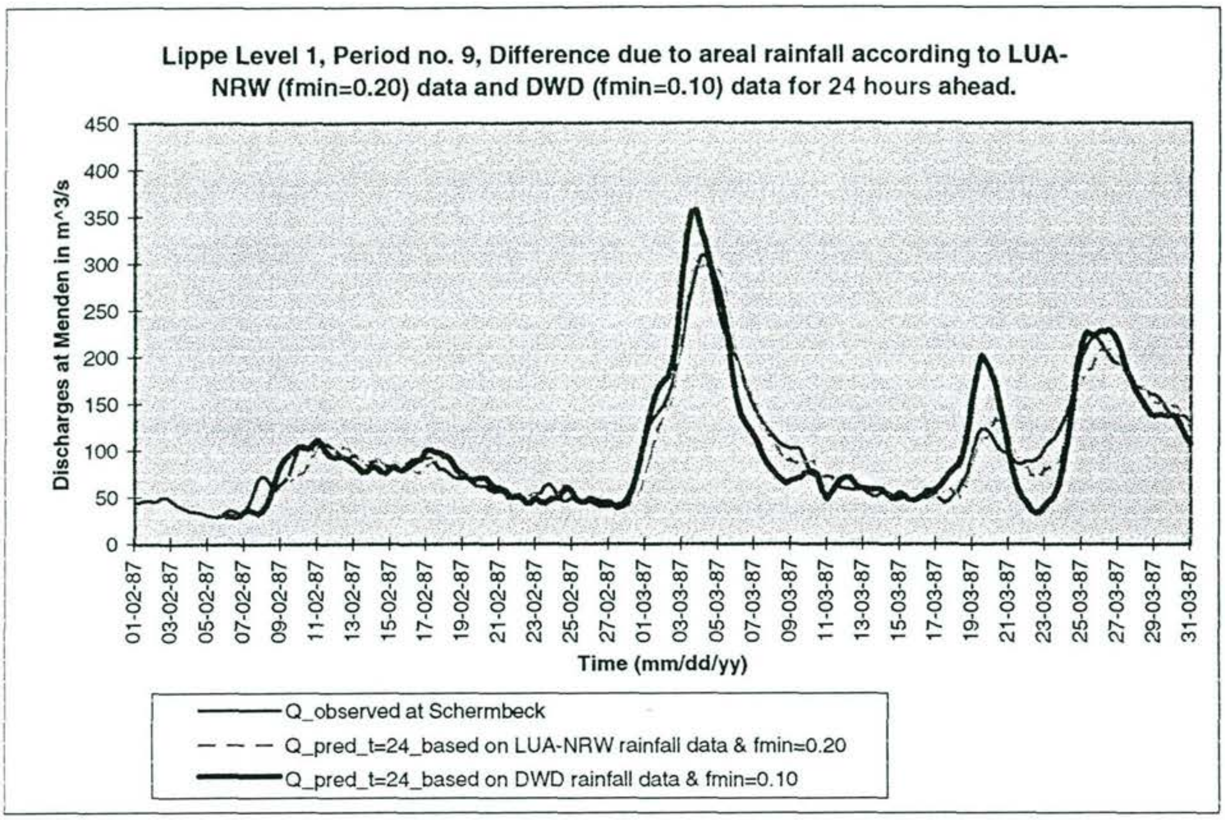


Fig. 10.24b Lippe Level 1, Period no. 9, Sensitivity to LUA-NRW and DWD areal rainfall, in both computations **fmin=0.20** was used.



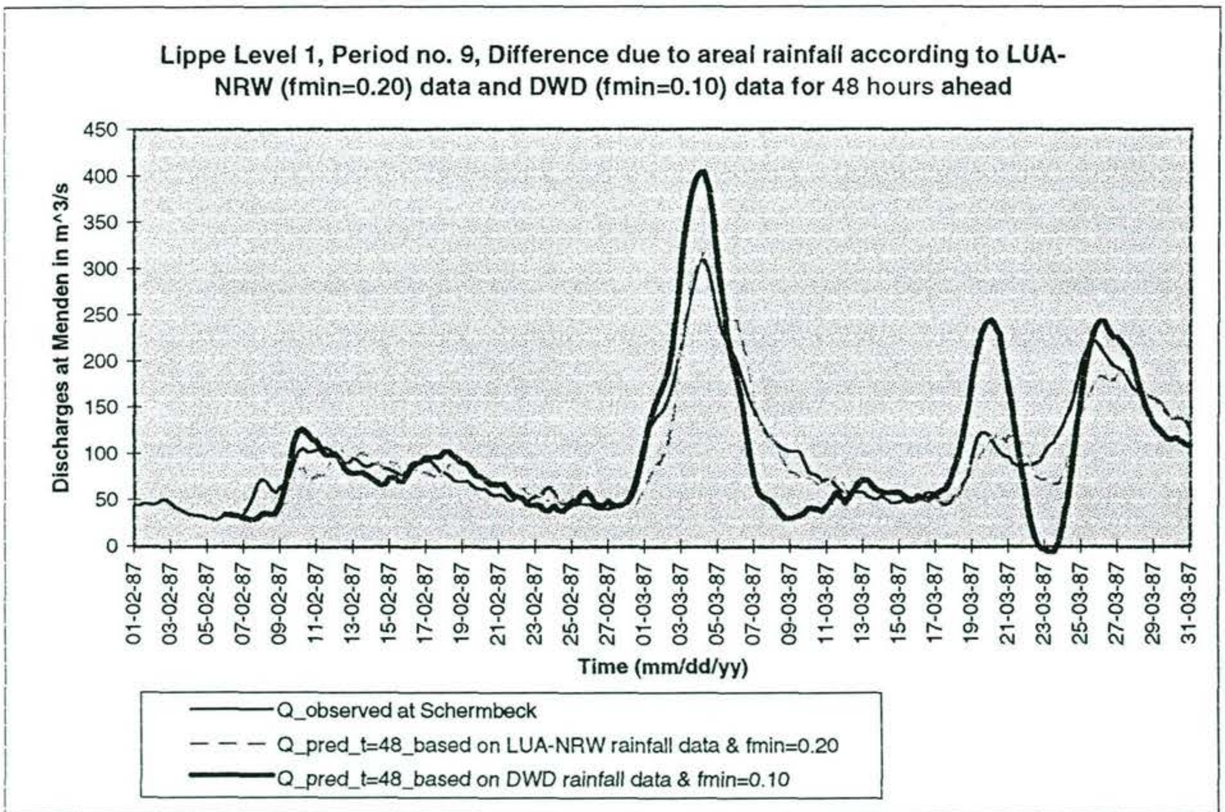


Fig. 10.25a Lippe Level 1, Period no. 9, Sensitivity to LUA-NRW and DWD areal rainfall, **fmin=0.20** for LUA-NRW & **fmin = 0.10** for DWD.

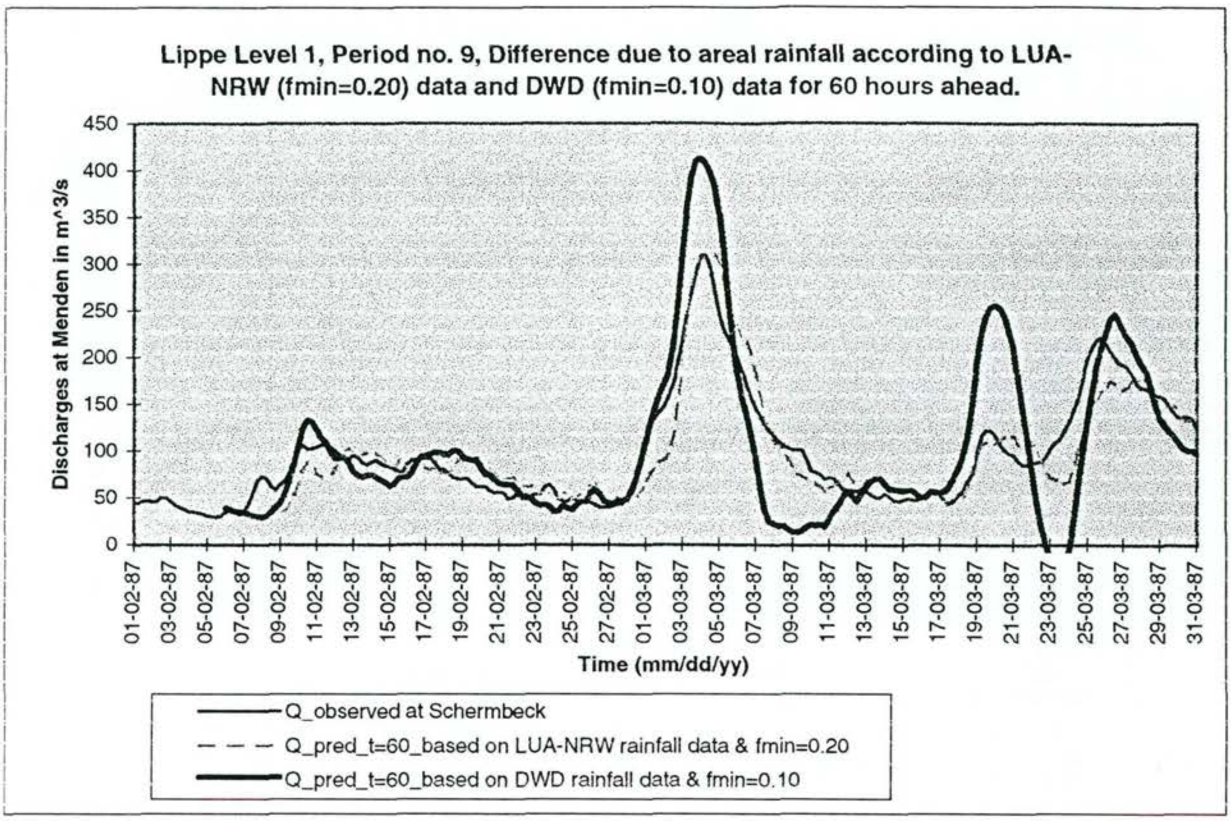
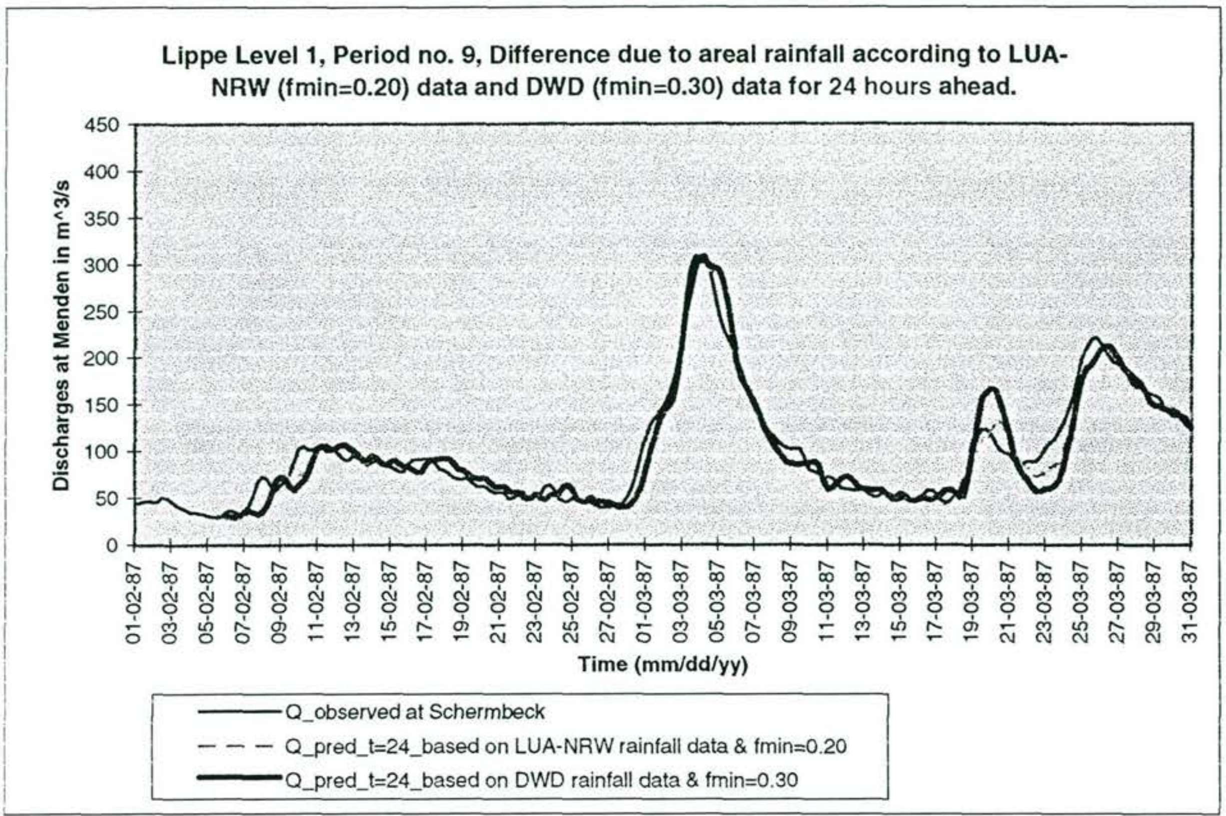


Fig. 10.25b Lippe Level 1. Period no. 9. Sensitivity to LUA-NRW and DWD areal rainfall. **fmin=0.20** for LUA-NRW & **fmin = 0.10** for DWD.



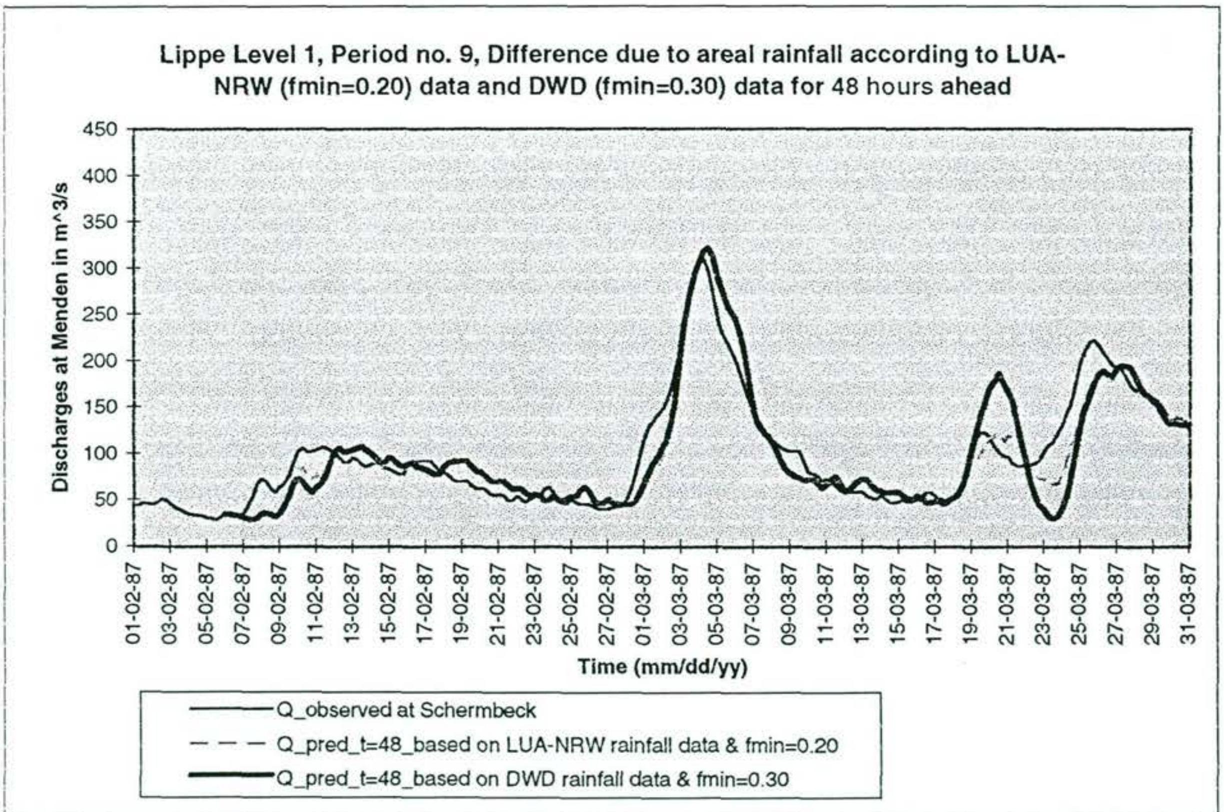


Fig. 10.26a Lippe Level 1, Period no. 9, Sensitivity to LUA-NRW and DWD areal rainfall, **fmin=0.20** for LUA-NRW & **fmin = 0.30** for DWD.

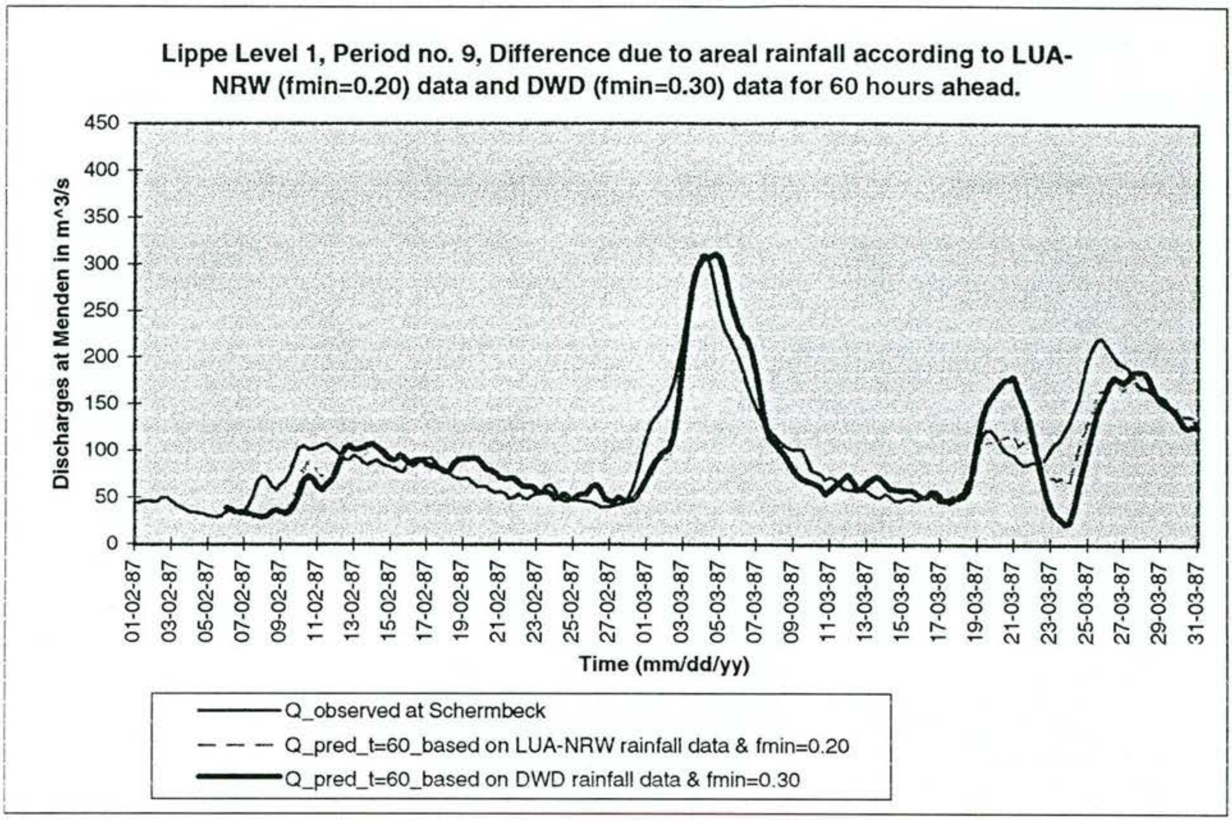


Fig. 10.26b Lippe Level 1, Period no. 9, Sensitivity to LUA-NRW and DWD areal rainfall, **fmin=0.20** for LUA-NRW & **fmin = 0.30** for DWD.

Figures of Chapter 11

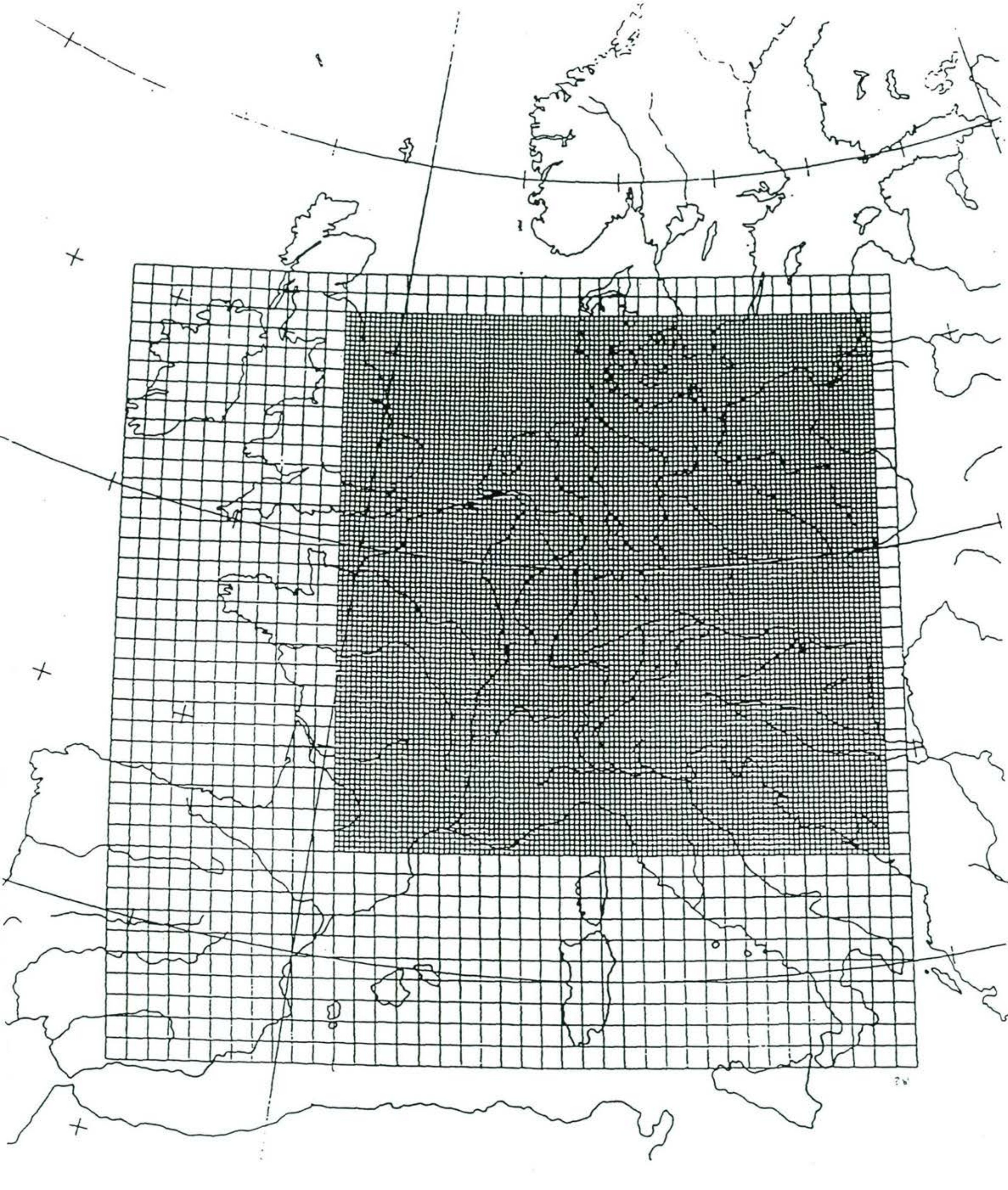


Fig. 11.1 Domain of the Deutschland-Modell (DM) and the Europa-Modell (EM)
Fine raster represents the DM

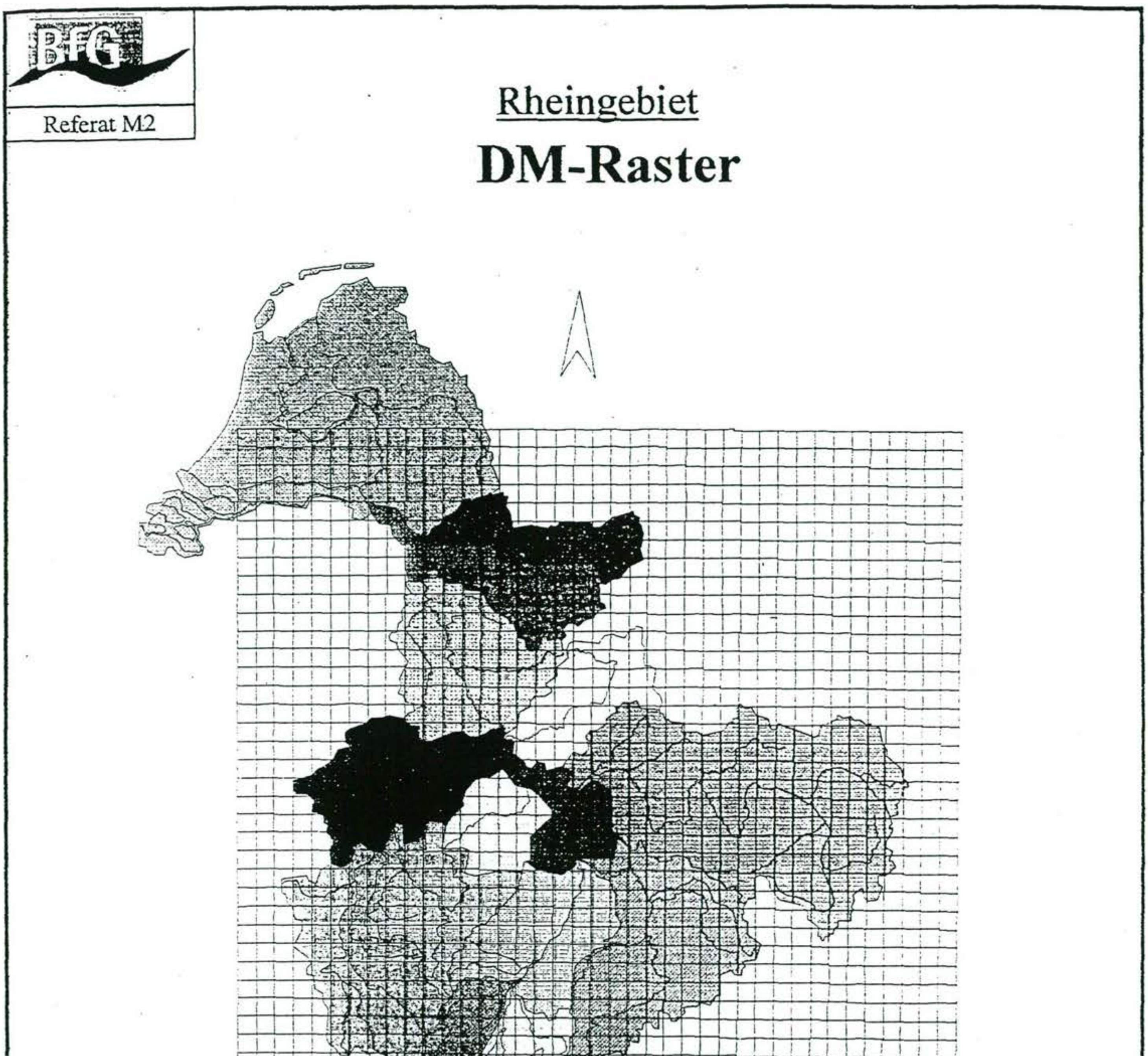


Fig. 11.2 Deutschland-Modell (DM) raster with the basin of the Rhine river

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