Joint management of Latvian – Lithuanian trans-boundary river and lake water bodies (TRANSWAT) LLI-533

REVIEW OF WATER DISCHARGE MEASUREMENTS

2022

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Abbreviations

AWB	Artificial Water Body;
E	East (in longitude coordinate)
E-flow	Ecological water flow
HPP	Hydropower Plant
H-Q curve	Water level – water discharge relationship rating curve
N	North (in latitude coordinate)

I. INTRODUCTION

Water discharge measurements were carried out in the frame of the “Joint management of Latvian – Lithuanian trans-boundary river and lake water bodies” project (TRANSWAT) LLI-533 financed by the Interreg V-A Latvia–Lithuania Programme 2014-2020.

River habitat suitability modelling and ecological flow (E-flow) evaluation procedure includes calculation of daily water flow in reference and altered conditions. Taking into account the lack of data for Varduva, Ciecere and Losis rivers, water discharge measurements were carried out upstream and downstream of HPPs on these rivers in order to describe the water level – water discharge relationship by creating the water level – water discharge rating curves (H-Q curves) for each of sites.

Number of measured water discharge differs from site to site due to ice conditions on the river in the winter season. Additionally to planned measurement for the H-Q curves’ creating the flow data measured during habitat surveys were used.

Varduva, Ciecere and Losis rivers measured water discharges and created H-Q curves are described in this Report.

II. WATER DISCHARGE MEASUREMENTS ON THE PILOT RIVER' SITES

Water discharges on the pilot river' sites were measured using different portable flow measuring devices with magnetic-inductive sensor for mobile flow measurement and the hydrological impellers for flow measurement. Measured water discharge data is used for creating H-Q curve and calculating of daily flow data series.

2.1. Water discharge in Varduva River

Almost for the last 50 years, the discharge measurements weren't been done in the Varduva River. Only the existing data for the period of 1956-1973 is available. After such a long break, the discharge was measured at least 9 times in each of 7 profiles (Table 2.1.1). The obtained discharge varied in a wide range depending on the profile. At the inflow profile of Varduva-Seda, the measured discharges fluctuated between 0.32 and 10.37 m^3/s. The profile below Kulšėnai HPP indicated similar enough values (0.36-10.66 m^3/s) since this HPP did not operate during the summer low-flow period. The highest amplitudes were found below of remaining HPPs that caused a dramatic decrease in discharge at the lower boundary of their hydropeaking. For example, below the Renavas and Vadagiai HPPs the lowest discharge was 0.16 m^3/s, meanwhile, the environmental flow for these HPPs is 0.39 and 0.41 m^3/s respectively. Similar runoff conditions were found below the Ukrinai HPP (environmental flow - 0.46 m^3/s) where the lowest measured value was just 0.15 m^3/s. The largest discharge (14.28 m^3/s) was measured on the bridge below Ukrinai HPP. Juodeikiai HPP was operated also in the wide range of hydropeaking. In several times the measured discharge was less than 0.40 m^3/s, although the environmental flow for this HPP is 0.91 m^3/s. Kvistė River distinguished near-natural runoff conditions therefore the discharges were evenly distributed between the amplitude of observations that fluctuated between 0.08 and 1.88 m^3/s discharge.

Table 2.1.1. Measured water discharges at 7 pilot sites of Varduva River and Kvistė River inflow

No.	Date of measurement	Time	Measured water discharge, m^3/sec
Varduva-Seda inflow to HPPs cascade (56.168283N, 22.081261E)			
1	18/11/2020	10:00 AM	1.69
2	15/12/2020	4:15 PM	1.80
3	10/05/2021	12:00 PM	3.49
4	13/05/2021	10:30 AM	2.65
5	12/07/2021	3:00 PM	0.46
6	02/08/2021	3:30 PM	0.32
7	05/08/2021	10:30 AM	0.47
8	17/08/2021	4:45 PM	0.48
9	14/09/2021	11:15 AM	0.59
Varduva-Seda inlow to HPPs cascade (bridge) (56.171747N, 22.090054E)			
10	01/03/2021	11:45 AM	5.77
11	02/03/2021	3:15 PM	3.84
12	22/11/2021	10:15 AM	10.37
Varduva downstream Kulšėnai HPP (56.184706N, 22.072611E)			
1	18/11/2020	10:45 AM	0.87
2	15/12/2020	3:00 PM	1.61
3	15/12/2020	3:30 PM	4.61
4	10/05/2021	1:45 PM	4.32
5	13/05/2021	11:15 AM	1.95
6	13/05/2021	11:30 AM	1.22
7	12/07/2021	12:45 PM	0.50
8	02/08/2021	11:15 AM	0.36
9	16/08/2021	11:00 AM	0.36
10	14/09/2021	12:00 PM	0.59
Varduva downstream Kulšėnai HPP (bridge) (56.224528N, 22.063255E)			
11	01/03/2021	1:45 PM	5.87
12	02/03/2021	2:00 PM	4.69
13	22/11/2021	1:45 PM	10.66
Varduva downstream Renavas HPP (56.234495N, 22.081502E)			
1	18/11/2020	11:45 AM	1.81
2	15/12/2020	2:15 PM	2.03
3	10/05/2021	2:45 PM	4.24

4	13/05/2021	2:45 PM	2.54
5	15/07/2021	10:30 AM	0.16
6	02/08/2021	12:00 PM	1.12
7	05/08/2021	3:45 PM	1.09
8	16/08/2021	1:15 PM	1.06
9	14/09/2021	3:00 PM	1.07
10	24/11/2021	3:30 PM	11.46
Varduva downstream Vadagiai HPP (56.256699N, 22.081421E)			
1	18/11/2020	12:45 PM	1.88
2	15/12/2020	1:30 PM	0.20
3	11/05/2021	1:00 PM	4.25
4	12/05/2021	3:00 PM	2.44
5	13/07/2021	4:00 PM	0.97
6	15/07/2021	4:00 PM	0.16
7	02/08/2021	2:45 PM	0.22
8	03/08/2021	3:00 PM	0.34
9	16/08/2021	3:00 PM	1.09
10	14/09/2021	4:00 PM	1.02
Varduva downstream Ukrinai HPP (56.298936N, 22.099972E)			
1	18/11/2020	2:45 PM	1.30
2	15/12/2020	11:30 AM	3.10
3	11/05/2021	10:45 AM	4.43
4	12/05/2021	10:30 AM	1.02
5	13/07/2021	10:15 AM	1.81
6	13/07/2021	12:00 PM	0.49
7	14/07/2021	3:15 PM	0.29
8	04/08/2021	3:45 PM	0.15
9	16/08/2021	4:15 PM	0.36
10	15/09/2021	2:15 PM	0.55
Varduva downstream Ukrinai HPP (bridge) (56.298936N, 22.099972E)			
11	01/03/2021	4:00 PM	7.19
12	02/03/2021	11:45 AM	6.19
13	23/11/2021	3:45 PM	14.28
Varduva downstream (Juodeikiai HPP 56.419768N, 22.201453E)			
1	18/11/2020	3:50 PM	3.57

2	15/12/2020	10:00 AM	3.23
3	11/05/2021	9:15 AM	6.55
4	12/05/2021	12:00 PM	4.34
5	14/07/2021	10:15 AM	0.36
6	14/07/2021	1:45 PM	2.52
7	03/08/2021	10:00 AM	0.27
8	15/09/2021	10:15 AM	0.40
9	15/09/2021	1:15 PM	1.80
Kvistė River inflow (56.326856N, 22.118244E)			
1	18/11/2020	2:15 PM	0.96
2	15/12/2020	12:00 PM	0.41
3	11/05/2021	11:45 AM	0.77
4	12/05/2021	11:00 AM	0.60
5	14/07/2021	4:15 PM	0.11
6	03/08/2021	1:15 PM	0.078
7	18/08/2021	3:30 PM	0.19
8	15/09/2021	3:45 PM	0.13
Kvistė River inflow (bridge) (56.322647N, 22.112646E)			
9	01/03/2021	5:00 PM	1.88
10	02/03/2021	11:00 AM	1.80
11	23/11/2021	2:45 PM	2.41

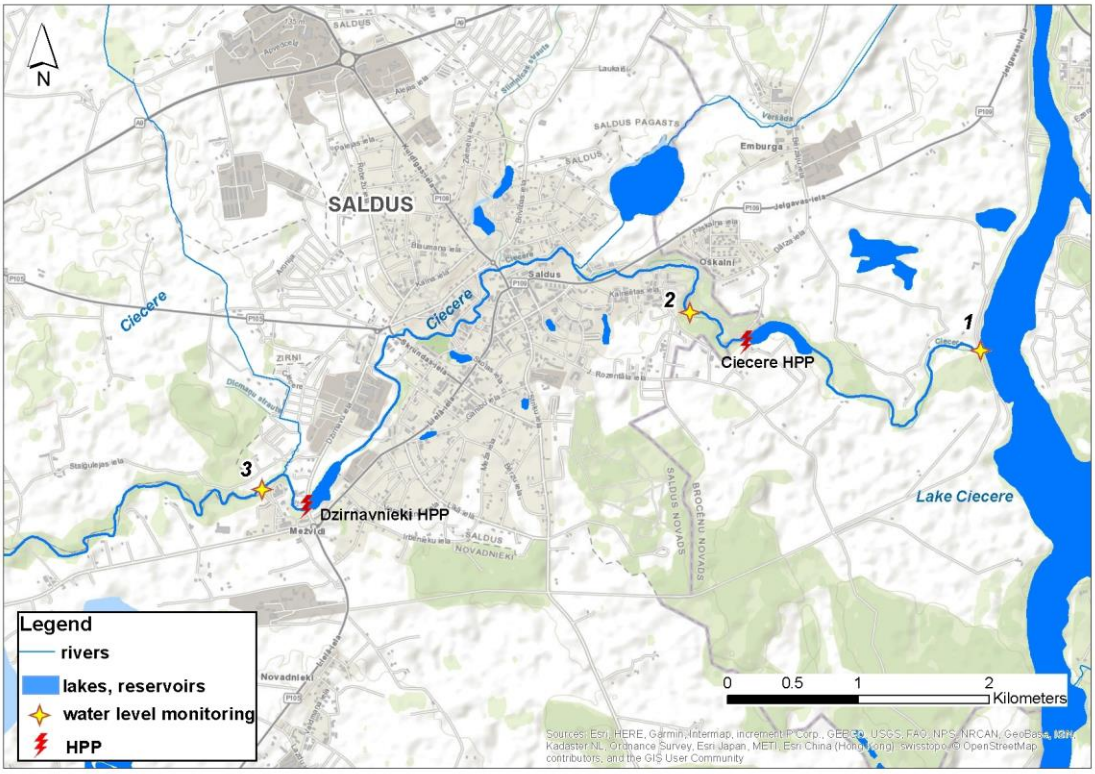
2.2. Water discharge in Ciecere River

There is one MS “Pakuli HPP” that located downstream the third HPP on Ciecere River. This MS provides water flow measurements and daily flow calculation. During the project water discharge measurements were carried out downstream two HPPs and upstream all of them in the following sites (Fig. 2.2.1):

1. Ciecere River headwaters near Ciecere Lake;
2. Ciecere River - Saldus park,

3. Ciecere River downstream Saldus.

Figure 2.2.1. Water flow measurements sites, Ciecere River



Water discharge measurements here were started in the end of November 2020 and carried out till the end of November 2021.

In the first site (Ciecere River headwaters near Ciecere Lake) 13 water measurements have been carried out. Hydrological regime of the Ciecere River' headwaters is naturally regulated by the Ciecere Lake, and the rate of measured flow in this site is from 0.10 m^3/sec to 1.06 m^3/sec (Tabula 2.2.1).

The second site (Ciecere River - Saldus park) is located downstream Ciecere HPP that regulates the flow regime of the Ciecere River. The rate of measured flow in this site varies from 0.06 m^3/sec to 1.38 m^3/sec (Tabula 2.2.1).

The third site (Ciecere River dowstream Saldus) is located downstream Dzirnavnieki HPP. Hydrological regime at this river stretch is regulated by both HPPs – the Ciecere HPP and the Dzirnavnieki HPP. The rate of measured flow in this site (Tabula 2.2.1) varies from 0.06 m^3/sec to 1.38 m^3/sec.

Table 2.2.1. Measured water discharges at 3 pilot sites of Ciecere River

No.	Date of measurement	Time	Measured water discharge, m^3/sec
1	**2**	**3**	**4**
Ciecere River headwaters near Ciecere Lake (56.6626N, 22.5526E)			
1	26/11/2020	3:25 PM	0.30
2	10/12/2020	10:40 AM	0.35
3	22/02/2021	10:40 AM	0.34
4	12/03/2021	10:20 AM	1.06
5	26/04/2021	09:30 AM	0.55
6	12/05/2021	09:00 AM	0.67
7	03/06/2021	11:44 AM	0.89
8	09/06/2021	09:50 AM	0.47
9	06/07/2021	09:00 AM	0.12
10	05/08/2021	09:30 AM	0.10
11	10/09/2021	10:05 AM	0.23
12	23/09/2021	11:30 AM	0.22
13	11/11/2021	10:35 AM	0.61
Ciecere River – Saldus park (56.6651N, 22.5163E)			
1	26/11/2020	02:55 PM	1.20
2	10/12/2020	11:10 AM	0.06
3	12/03/2021	11:05AM	1.18
4	26/04/2021	11:50 AM	0.94
5	12/05/2021	09:20 AM	0.65
6	03/06/2021	09:10 AM	0.89
7	09/06/2021	05:40 PM	1.15
8	06/07/2021	10:00 AM	0.10
9	05/08/2021	10:30 AM	0.07
10	10/09/2021	10:30 AM	0.07
11	23/09/2021	12:05 AM	0.16
12	05/11/2021	11:40 AM	0.82
13	25/11/2021	01:35 PM	1.38
Ciecere River – downstream Saldus (56.6524N, 22.4634E)			
1	26/11/2020	02:15 PM	0.21
2	10/12/2020	11:45 AM	1.48

3	22/02/2021	11:25 AM	0.56
4	12/03/2021	11:40 AM	1.75
5	26/04/2021	10:45 AM	0.28
6	12/05/2021	10:45 AM	0.21
7	03/06/2022	11:30 AM	2.13
8	09/06/2021	10:40 AM	0.27
9	06/07/2021	10:45 AM	0.30
10	05/08/2021	11:20 AM	0.38
11	10/09/2021	11:00 AM	0.43
12	23/09/2021	10:40 AM	0.28
13	05/11/2021	01:00 PM	2.19

2.3. Water discharge in Losis River

There is no one monitoring station on the Losis River. During the project water discharge measurements were carried out downstream two HPPs and upstream all of them in the following sites (Fig. 2.3.1):

1. Losis River – LT-LV state border;
2. Losis River – Kalni;
3. Losis River – downstream Kanaviski pond.

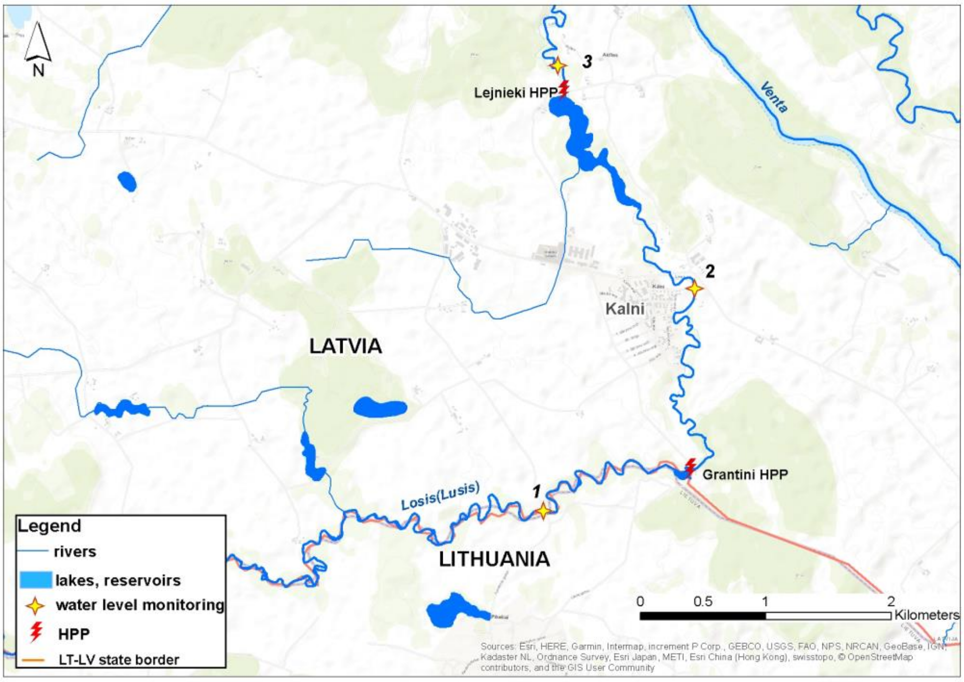


Figure 2.3.1. Water flow measurements sites, Losis River

Water discharge measurements in the Losis River were started in the end of November 2020 and carried out till the middle of November 2021.

In the first site (Losis River – LT-LV state border Lake) 11 water measurements have been carried out. There is a natural hydrological regime, and the rate of measured flow in this site is from 0.19 m^3/sec to 4.63 m^3/sec (Tabula 2.3.1).
The second site (Losis River – Kalni) is located downstream Grantini HPP that regulates the flow regime of the Losis River. 13 water measurements have been carried out here during the project. The rate of measured flow in this site varies from 0.065 m^3/sec to 2.42 m^3/sec (Tabula 2.3.1).
The third site (Losis River – downstream Kanaviski pond) is located downstream Lejnieki HPP. Hydrological regime at this river stretch is regulated by both HPPs – the Grantini HPP and the Lejnieki HPP. 14 water measurements have been carried out here during the project. The rate of measured flow in this site (Tabula 2.3.1) varies from 0.11 m^3/sec to 4.05 m^3/sec.

Table 2.3.1. Measured water discharges at 3 pilot sites of Losis River

No.	Date of measurement	Time	Measured water discharge, m^3/sec
1	**2**	**3**	**4**
Losis River – LT-LV state border (56.4285N, 22.1145)			
1	26/11/2020	10:40AM	2.76
2	12/03/2021	09:50 AM	2.73
3	27/04/2021	09:10 AM	2.69
4	21/05/2021	03:40 PM	0.72
5	11/06/2021	12:40 AM	0.26
6	14/07/2021	10:05 AM	0.19
7	11/08/2021	07:00 AM	0.94
8	12/08/2021	05:50 PM	0.25
9	02/09/2021	09:50 AM	0.56
10	28/09/2021	11:40 AM	0.45
11	10/11/2021	10:50 AM	4.63
Losis River – Kalni (56.4448N, 22.1333 E)			
1	20/10/2020	01:40 PM	1.34

2	21/10/2020	09:35 AM	0.065
3	26/11/2020	11:40 AM	2.18
4	10/12/2020	11:50 AM	2.15
5	22/03/2021	11:35 AM	2.33
6	21/05/2021	11:30 AM	1.35
7	11/06/2021	10:00 AM	1.35
8	14/07/2021	10:50 AM	0.89
9	11/08/2021	08:55 AM	0.37
10	11/08/2021	10:55 AM	0.090
11	02/09/2021	10:35 AM	0.10
12	28/09/2021	10:25 AM	0.084
13	10/11/2021	11:35 AM	2.42
Losis River – downstream Kanaviski pond (56.4605N, 22.1148E)			
1	20/10/2020	09:30 AM	0.074
2	26/11/2020	12:40 AM	2.14
3	10/12/2020	01:00 PM	2.39
4	25/01/2021	02:05 PM	2.23
5	16/02/2021	12:35 AM	0.19
6	22/03/2021	11:25 AM	2.03
7	27/04/2021	08:00 AM	0.33
8	21/05/2021	12:00 AM	0.20
9	11/06/2022	10:50 AM	0.11
10	14/07/2021	11:30 AM	1.69
11	11/08/2021	11:55 AM	0.425
12	02/09/2021	11:10 AM	2.19
13	08/10/2021	10:00 AM	2.10
14	10/11/2021	12:20 AM	4.05

III. WATER LEVEL - WATER DISCHARGE RELATIONSHIP

River discharge is the variable that is usually required for hydrological analysis but, continuous measurement of the past discharge is time and financially consuming. However, the water level is a more flexible variable in continuous recording with relatively less consuming efforts. Water level can be observed continuously or at regular short time intervals with comparative ease and economy. Fortunately, the relation exists between the water level and the corresponding discharge at target river profile. This relation is expressed as water level-discharge rating curve or H-Q curve. The flexibility of this curve consists of incoherent measurements of water discharge as well as the data gaps can be easily estimated from the obtained relation. The only required condition consists of the measurements at boundary conditions and as the wider amplitude of measurements as it is possible. More data provide an opportunity to create more precise relation at a profile.

3.1. Water level-discharge rating curves in Varduva River

In the case of the Varduva River, seven water level-discharge rating curves represented by seven profiles of interest were created. At each of the profiles, the water leveloggers were installed and measured the water level every 15 minutes. Additionally, water discharge was measured at least 8 times per profile (Table 2.1.1). According to the collected data and extrapolated values for high discharges at the profiles where measurements of high discharges were unable, the relations between the recorded water level at certain time and the measured discharge at the same time were created for mentioned profiles (Fig. 3.1.1). The obtained relations showed a strong correlation (0.99) at each of analysed profiles. Accordingly, the water level-discharge rating curves were ready to be applied for discharge calculations using water levels recorded by water leveloggers.

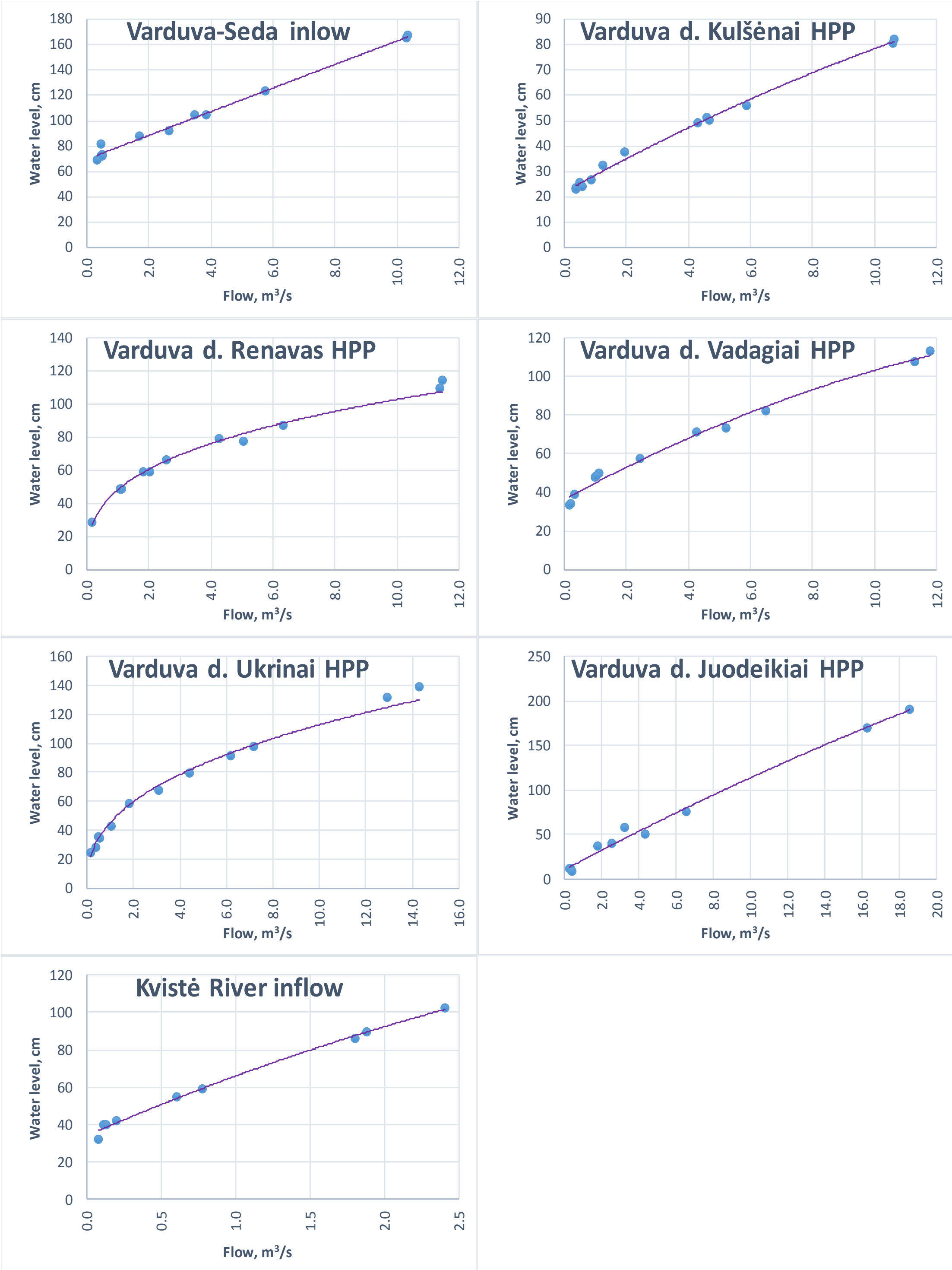


Figure 3.1.1. Relations between water discharge and water level in Varduva and Kvistė inflow, and downstream (d.) HPPs

3.2. Water level-discharge rating curves in Ciecere River

The water level – water discharge rating curve for the sites in the Ciecere River are developed using HYMER programme that allow to deselect insufficient measurements due to ice or aquatic vegetation impact as well as technical errors.

In the case of the first site (Ciecere River headwaters near Ciecere Lake) from 13 measurements 2 were flagged due to technical errors and 3 – due to aquatic vegetation impact (Fig. 3.2.1).

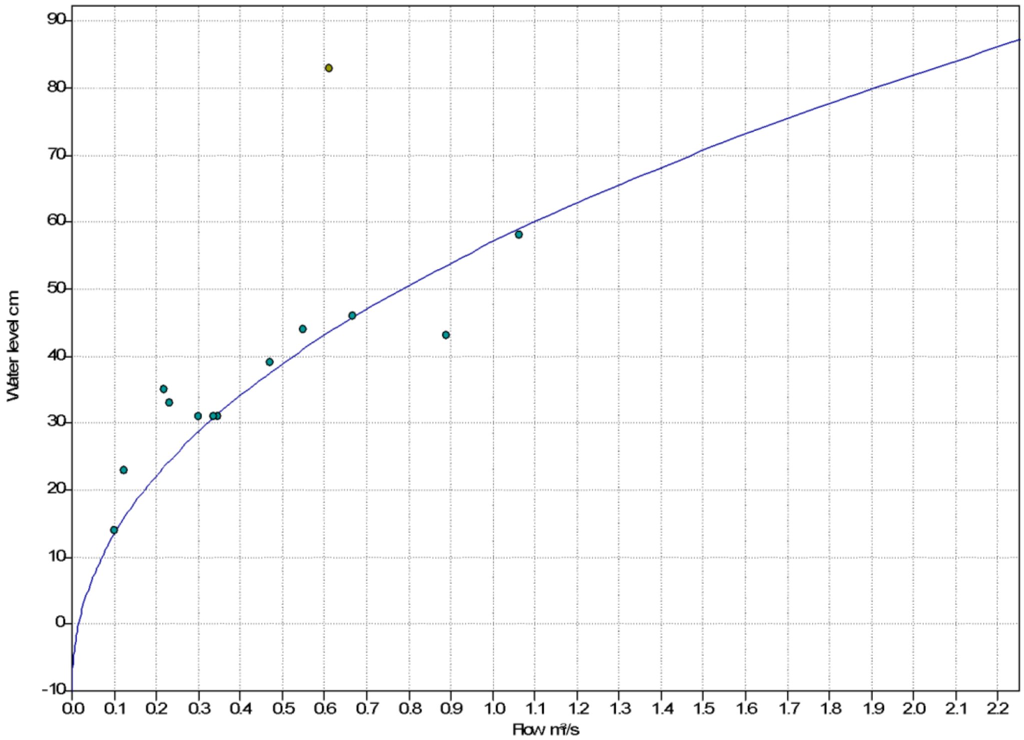


Figure 3.2.1. Relations between water discharge and water level in Ciecere River headwaters near Ciecere Lake

In the second site (Ciecere River - Saldus park) all 13 measurements were accepted for the rating curve development (Fig. 3.2.2).

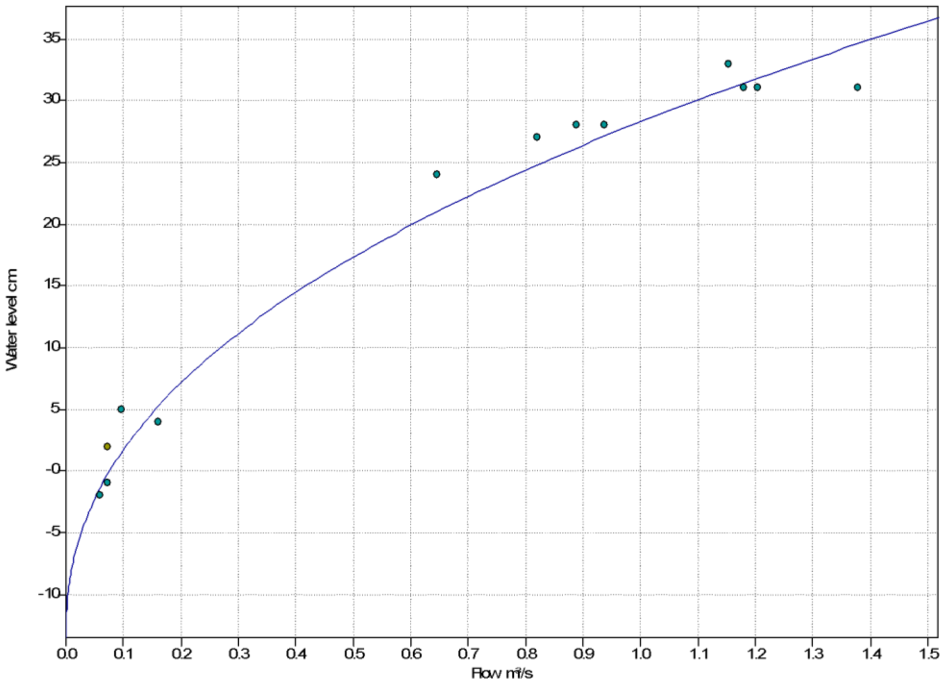


Figure 3.2.2. Relations between water discharge and water level in Ciecere River - Saldus park

In the third site (Ciecere River dowstream Saldus) from 13 measurements 2 were flagged due to aquatic vegetation and 1 due to ice phenomena impact (Fig. 3.2.3).

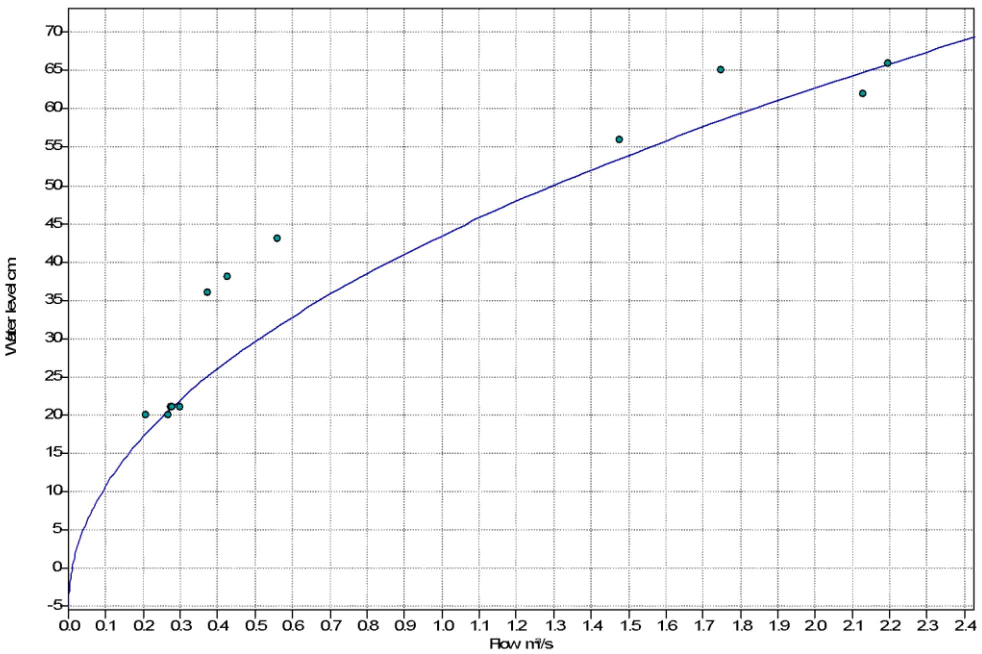


Figure 3.2.3. Relations between water discharge and water level in Ciecere River downstream Saldus

3.3. Water level-discharge rating curves in Losis River

The water level – water discharge rating curve for the sites in the Losis River are developed using HYMER programme that allow to deselect insufficient measurements due to ice or aquatic vegetation impact as well as technical errors.

In the case of the first site (Losis River – LT-LV state border) all 11 measurements were accepted for the rating curve development (Fig. 3.3.1).

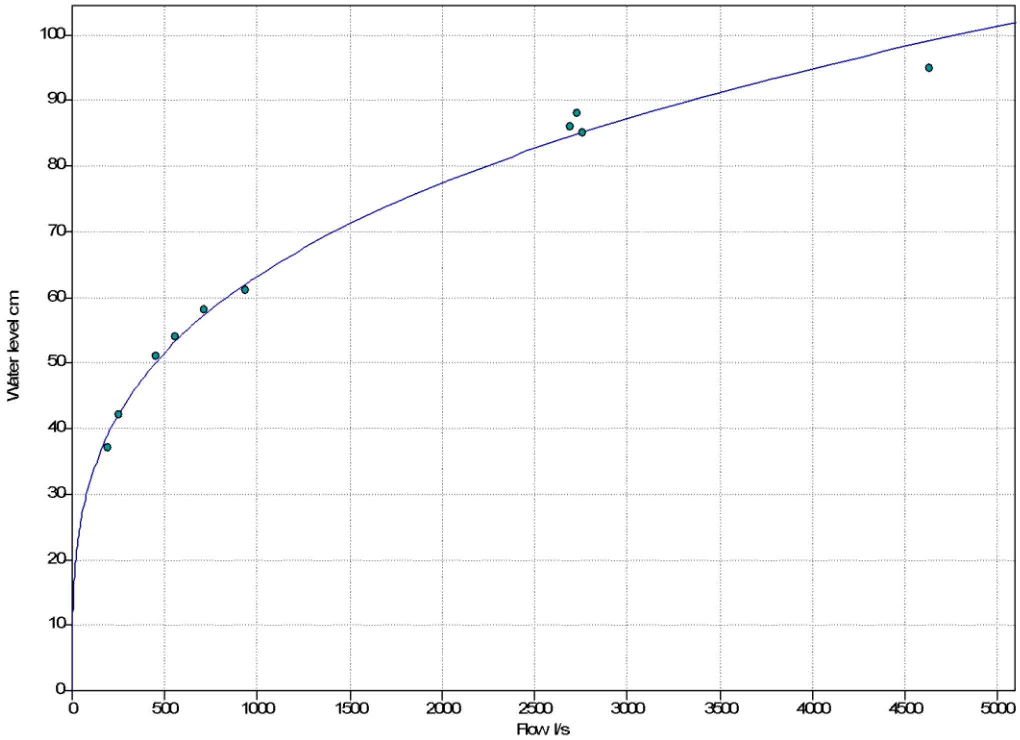


Figure 3.3.1. Relations between water discharge and water level in Losis River at LT-LV state border

In the case of the second site site (Losis River – Kalni) from 12 measurements 1 was flagged due to technical errors and 2 – due to aquatic vegetation impact (Fig. 3.3.2).

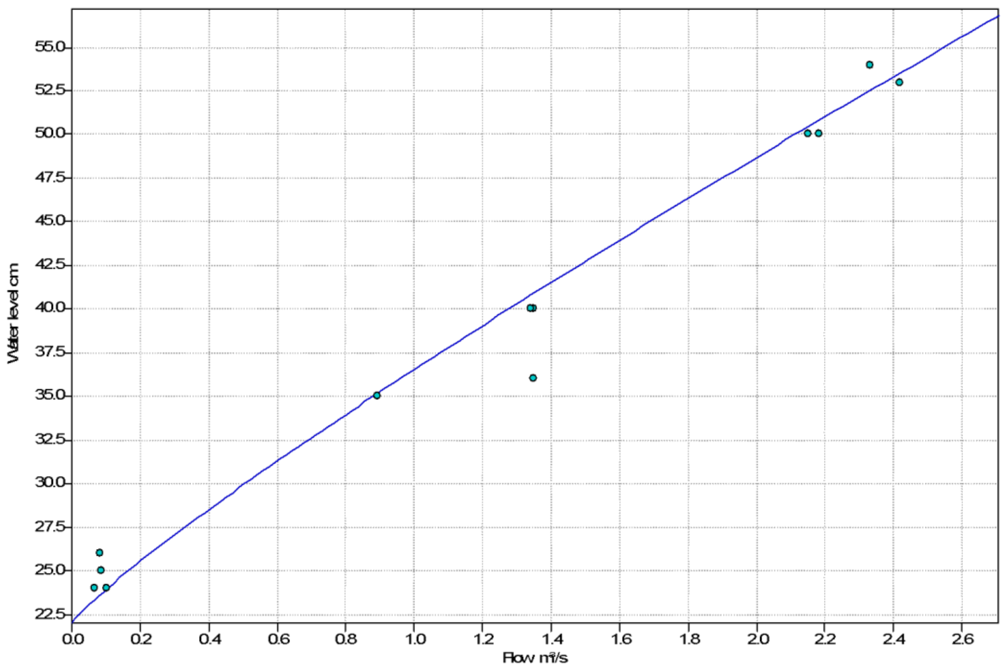


Figure 3.3.2. Relations between water discharge and water level in Losis River at Kalni

In the third site (Losis River – downstream Kanaviski pond) from 13 measurements 3 were flagged due to aquatic vegetation impact and 1 due to technical error (Fig. 3.2.3).

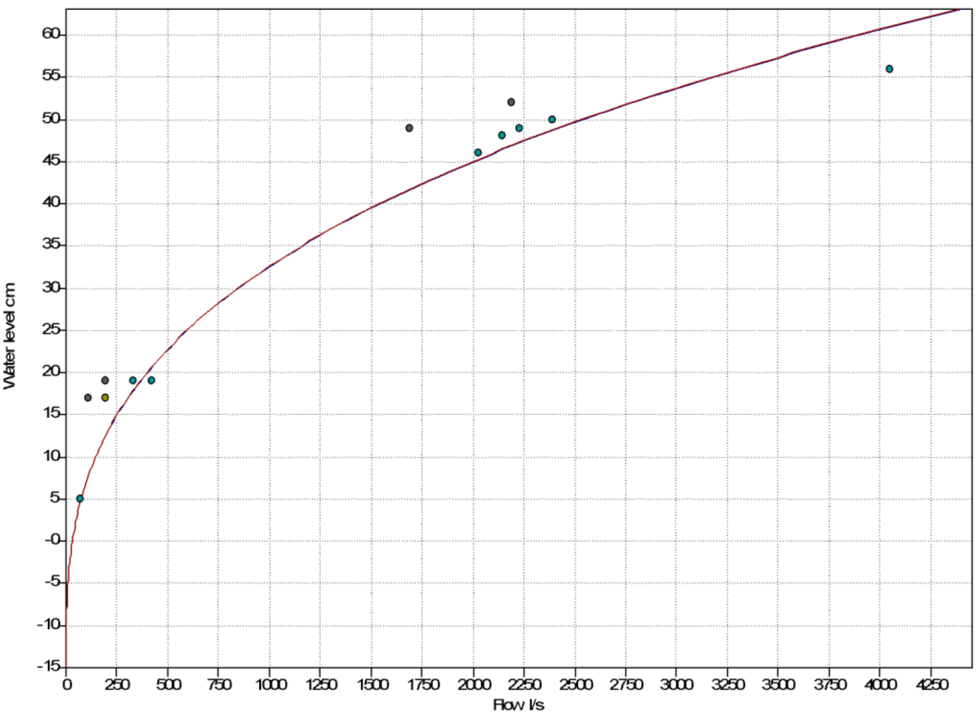


Figure 3.3.3. Relations between water discharge and water level in Losis River downstream Kanaviski pond

IV. CONCLUSIONS

The water flow measurements were carried out in 6 pilot sites of Varduva River, 3 sites of Ciecere River and 3 sites of Losis River during period of October 2020 – November 2022. Additionally, the water discharge was measured in 1 tributary of Varduva River.

According to measured discharges and available water level data, the water level-discharge rating curves were created.