PRILOGA 2E

Report

of the Hydrology Working Sub-group for the

Drava River

2019

REPUBLIKA SLOVENIJA
MINISTRSTVO ZA OKOLJE IN PROSTOR
AGENCIJA REPUBLIKE SLOVENIJE ZA OKOLJE

LAND KÄRNTEN
Abt. 12 – Wasserwirtschaft

HYDRO grafie
Kärnten
... am Puls des Wassers.

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1 MINUTES

of the 5th meeting of the Working subgroup for Hydrology for the Drava River,

Working group "Water Management"

Ljubljana, Slovenia, March 13, 2019

1.1 Attendance

In accordance with paragraph 2.7 of the minutes of the 27th session of the Permanent Slovenian-Austrian Commission for the Drava (11 to 12 September 2018), 5th meeting was held at the Slovenian Environment Agency.

The meeting was chaired by Dr Mira Kobold, head of the working subgroup on the Slovenian side.

A list of attendance is enclosed.

1.2 Adoption of the agenda

The following agenda was adopted:

1. Hydrological data of the Drava River for 2018
2. Suspended load of the Drava
3. Data exchange, operation of the forecasting services and communication during the high waters and floods
4. Flood forecasting model of the Drava River
5. The common hydrometric measurements at the border profile and hydrometric data exchange
6. Miscellaneous

1.2.1 Hydrological data for 2018

Hydrography of Carinthia:

- gauging station Lavamünd / KW Lavamünd MQ = 283 m^3/s
- Lavant / Pegel Krottendorf: MQ = 12,8 m^3/s
- mean discharge of the Drava River at Lavamünd Grenze: MQ = 296 m^3/s
- highest flood discharge of the Drava River at Lavamünd Grenze: HQ = 1630 m^3/s (HQ_7)

Verbund:

- Drava at the powerplant Lavamünd (without Lavant): MQ = 283 m^3/s

ARSO:

- gauging station Črneče: MQ = 313 m^3/s (determination of mean annual discharge is unsatisfied)
- highest flood discharge of the Drava River at Črneče: HQ = 1525 m^3/s (29.10.2018; missing data betveen 29.10. and 2.11.2018)

DEM:

- Drava at hydropower plant Dravograd MQ = 290 m^3/s
- highest flood discharge at hydropower plant Dravograd: HQ = 1589 m^3/s (30.10.2018)

Water balance of Carinthia:

	2018 (mm)	1981-2010 (mm)	Deviation of annual values from the period (%)
Precipiation	1250	1198	+4,3
Flow rates	744	593	+25,8
Evapotranspiration	625	582	+7,4

Temporary buffer: -119 mm (snowmelt; Precipitation 2017)

1.2.2 Suspended load of the Drava

Austrian side presented the results of analyses of suspended load for the year 2018. Slovenian Environment Agency (ARSO) does not monitor the turbidity and suspended load of the Drava River in the frame of national monitoring. The monitoring on the Drava River is performed by DEM company. For 2018, turbidity data for HP Dravograd are not available for most of the year and analysis of suspended load has not been made. The

upgrade of measuring station in Dravograd for monitoring of turbidity is in progress.

HD Kärnten calculates the yearly balance of suspended load for four stations on the Drava river and tributaries.

Suspended load for 2018 of Drava Lavamünd Ort: 1,0 million tons.

Suspended load for 2018 of Drava Lavamünd Grenze: 1,07 million tons.

1.2.3 Data exchange, operation of the forecasting services and communication during the high waters and floods

The system of SMS messages and E-mails works well and the communication during high waters between forecasting services is good. The automated dissemination procedure is operational and is not experiencing any problems.

ARSO is the only contact institution for hydrological data transfer between Carinthia and Slovenia and data for DRAVA-model of ARSO.

If data are used for other projects in Slovenia, ARSO can transfer Carinthian data to those users. An agreement with the Carinthian hydrological service for those data transmissions to other organisations is necessary.

The operative hydrological and meteorological data exchange between ARSO and HD Kärnten was established in 2013. In spring 2018, the data exchange protocol was improved (exchanging 8h trailing data records) by both institutions so there is less missing Kärnten data in the ARSO database. Later, in autumn 2018, the protocol was additionally improved by HD Kärnten when they also started exchanging last 10 days data once daily. This was done to provide quality checked data for the past few days. Moreover, for the Drava flood forecasting modelling purposes at ARSO, additional meteorological and hydrological station of the HD Kärnten observational network were included in the data exchange.

At the meeting, ARSO inquired about receiving the HP operational plans as additional data for the purpose of hydrological forecasting. DEM representative confirmed that they can provide the data via email and will start the procedure in due time. The Verbund representative also complied with the agreement.

1.2.4 Flood forecasting model of the Drava River

In early autumn 2018, ARSO has established an operational setup of the Drava River hydrological model with observed meteorological data on the input side from six observational networks. The representatives of HD Kärnten visited ARSO in September 2018 for a deep insight and broad and fruitful expert conversation about the modelling of the Drava

catchment. During the early operation of the model significant flood event occurred in the Austrian part of the Drava catchment. The model results along with interpretations were exchanged with the colleagues from HD Kärnten via email during the event. It was concluded that the model results were overestimating the actual catchment response. Afterwards, HD Kärnten prepared comprehensive report about the flood event with special focus on the retention areas in the catchment. The information from the report will be used for improvement of the ARSO model.

1.2.5 The common hydrometric measurements at the border profile and hydrometric data exchange

Common discharge measurements in 2019 will be at fixed dates, proposed by Hydrography of Carinthia (HD Kärnten) at least two weeks in advance. The main goal is to calibrate side-looking Doppler current profilers, namely H-ADCP in gauging station Črneče (ARSO) and OTT SLD in gauging station Lavamünd Grenze (KTN).

Considering troubles and frequency of discharge measurements made so far, flows lower than 150 m^3/s and higher than 800 m^3/s are the most important. Low flows, their stability and duration, need to be agreed with HP plant managers from both countries, Slovenian DEM and Austrian Verbund. Discharge measurements of high flows can effectively be planed using Flood forecasting model of the Drava River. In both cases, all participants will have to establish certain procedure how to make common measurement work in monthly/yearly practice.

By far the safest and most applicable discharge measurement method in general is cableway system. To make the most effect out of common measurements we should use the newly established, modern equipment at gauging station Lavamünd Grenze. Therefore, ARSO is extremely grateful and looking forward to this year's cooperation and progress.

Since there has been some heavy snowfall in the catchment area this winter new measurements are planned to be realized soon - in one month.

1.2.6 Miscellaneous

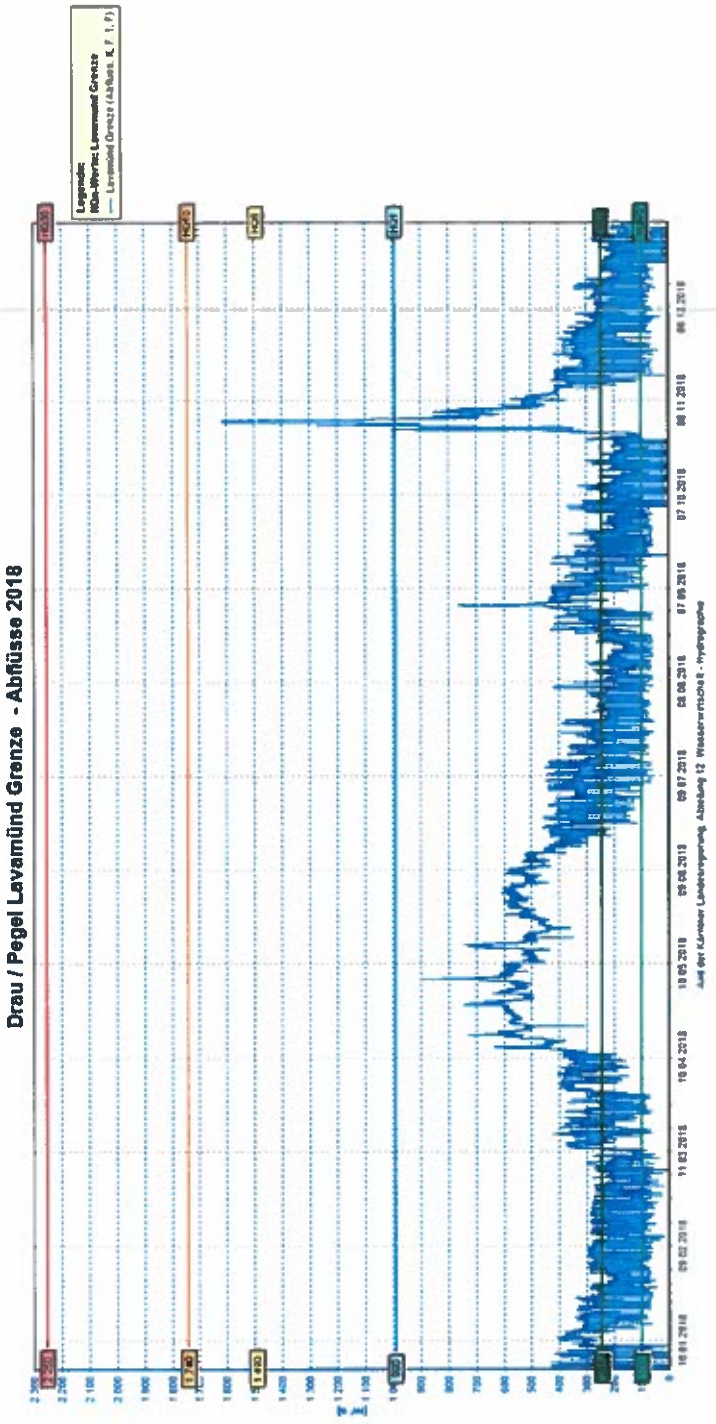
Prepared by:

Dr Mira Kobold and DI Johannes Moser

2 DATA - HD KÄRNTEN

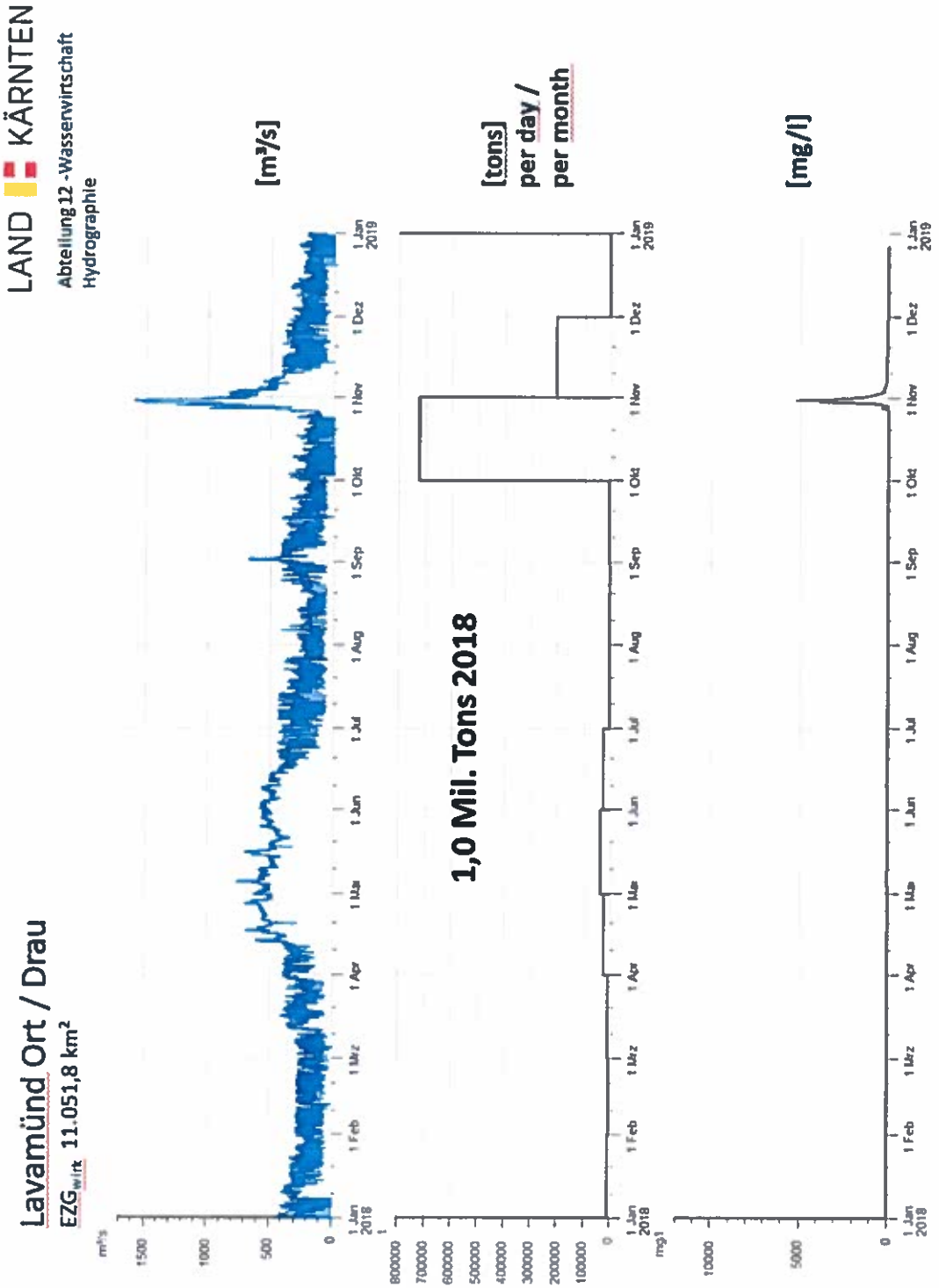
- Discharges 2018: Drava: Lavamünd with Lavant
- Suspended load 2018
- Suspended load 2009 – 2018
- Water balance of Carinthia 2018

2.1 Discharges 2018 Drava River: Lavamünd with Lavant (Lavamünd Grenze)

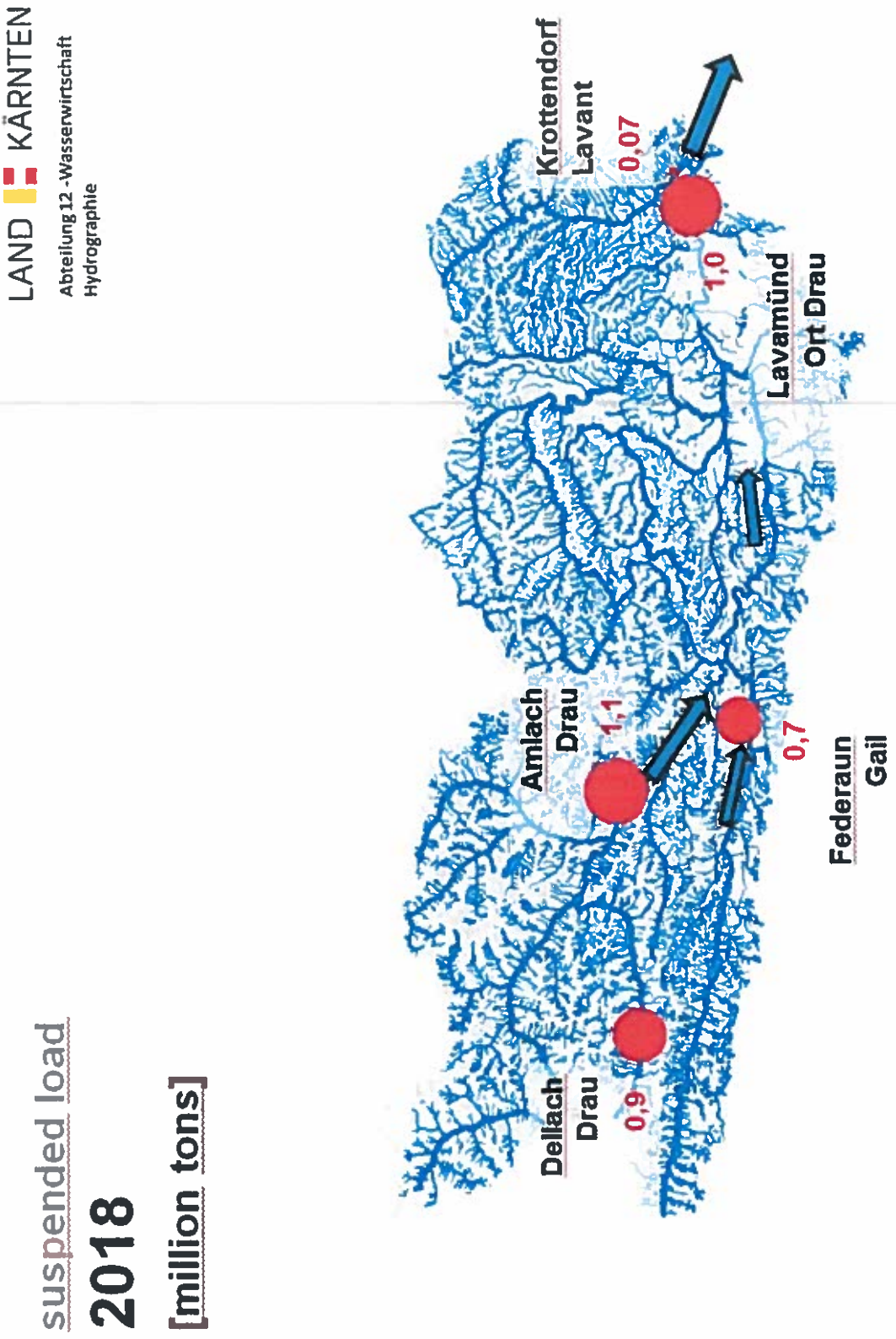


2.2 Suspended load 2018

Lavamünd Ort 2018 (without Krottendorf / Lavant)



Measuring points - Carinthia 2018



2.3 Measured suspended load 2009 - 2018

suspended load [million tons]
2009 – 2018

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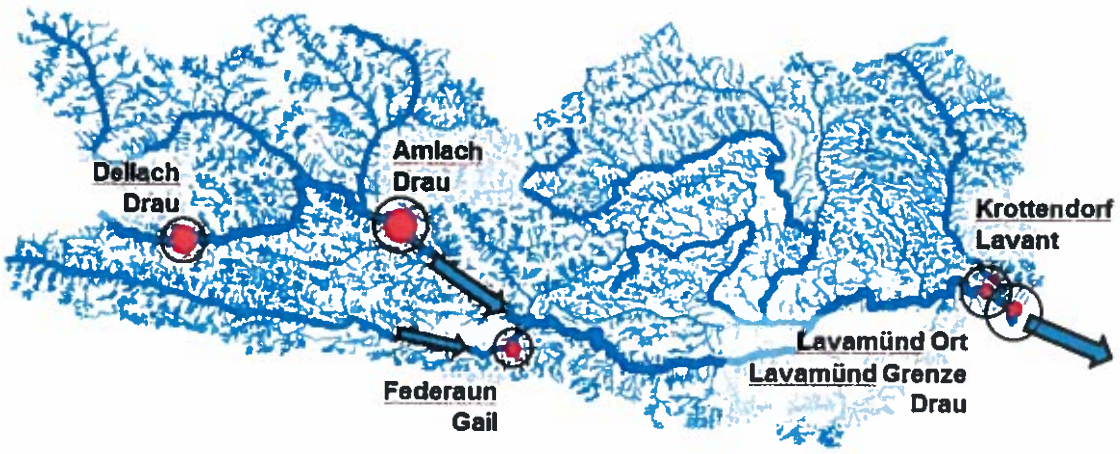
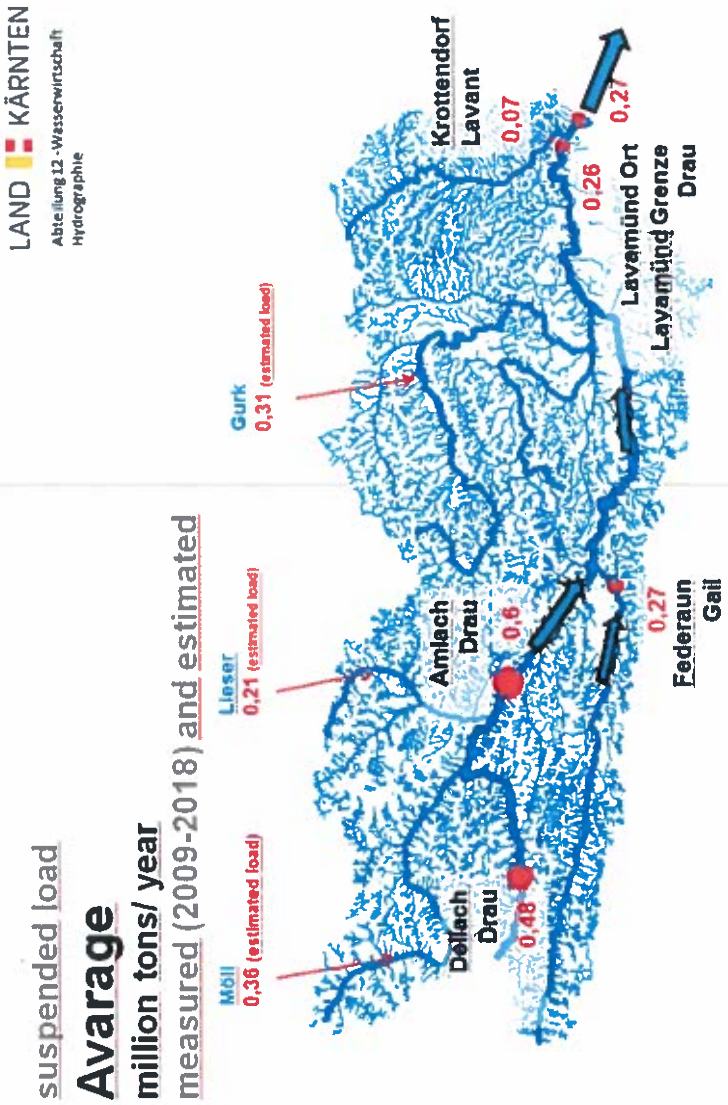
Abteilung 12 - Wasserwirtschaft
Hydrographie

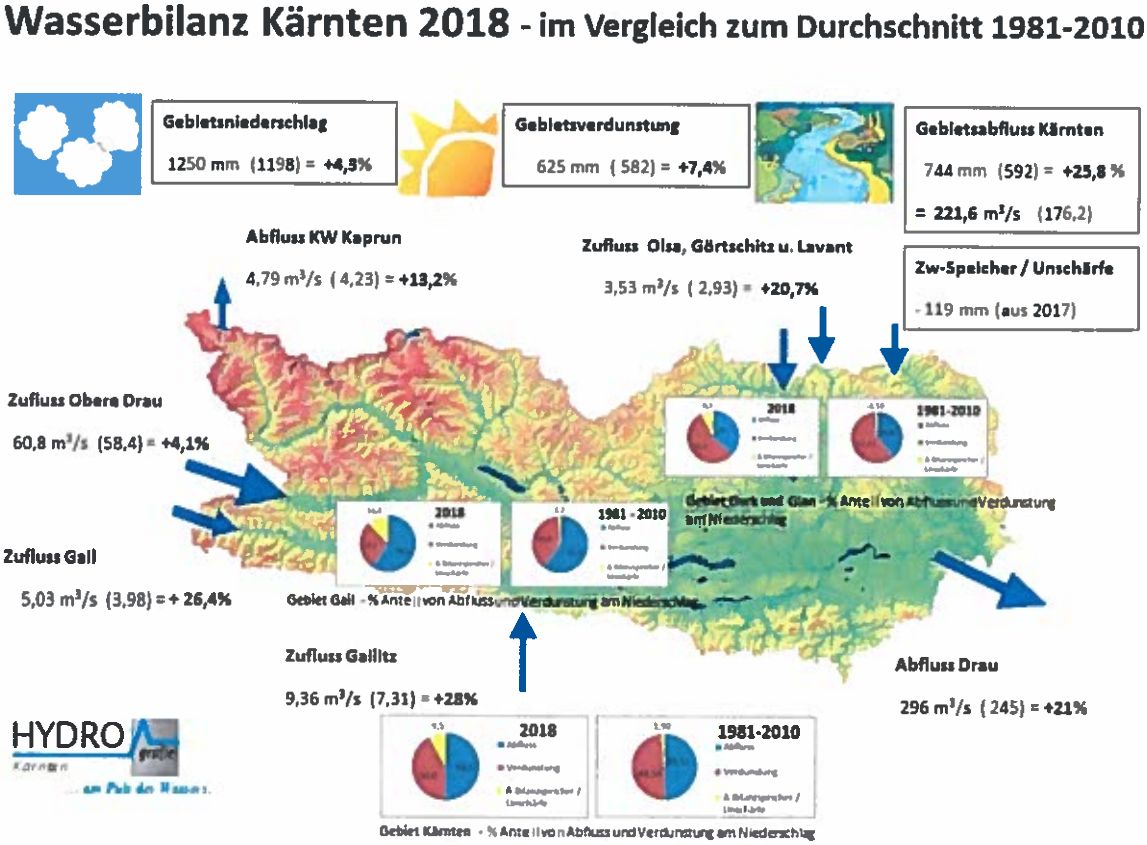
measuring points	Avarage per year (2009 – 2018) Mil. t	Sum 2018 Mil. t	catchment area km²	Sum 2009 - 2018 Mil. t
Dellach / Drau	0,5	0,9	2.198,6	4,8
Amlach / Drau	0,6	1,1	4.713,5	6,0
Federaun / Gail	0,27	0,7	1.304,9	2,7
Lavamünd Ort / Drau	0,26	1,0	11.051,8	2,6
Krottendorf / Lavant	0,07	0,07	954,50	1,3



2.4 Annual average of suspended load

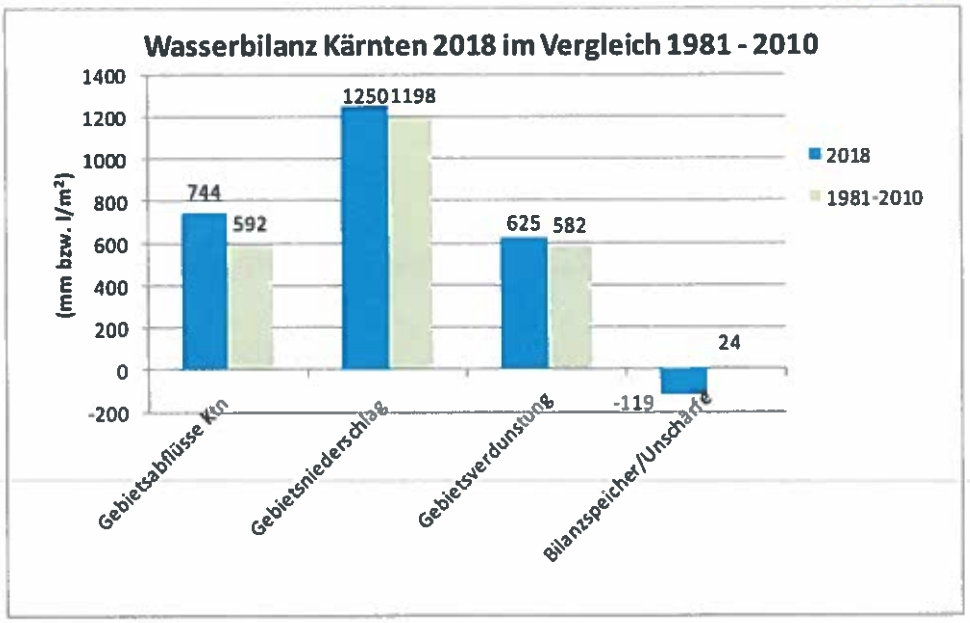


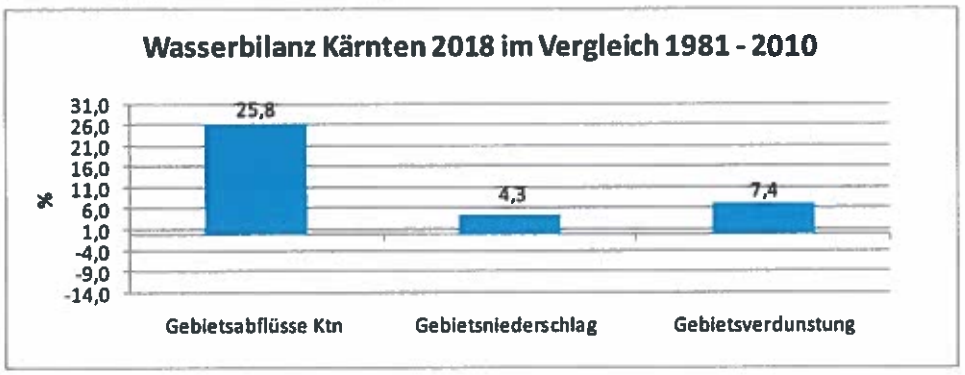
2.5 Water balance of Carinthia 2018



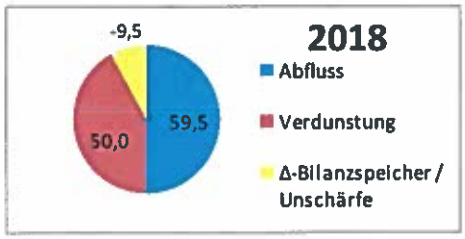
Wasserhaushalt Kärnten

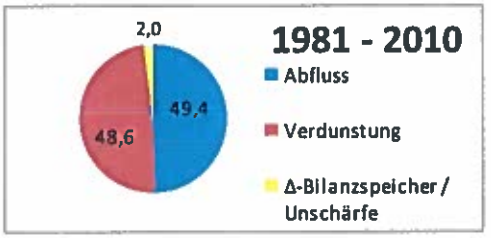
Bilanz 2018 im Vergleich zur Periode 1981 - 2010





% -Anteile des Abflusses und der Verdunstung am Niederschlag 2017 und der Periode 1981-2010





Zu- und Abflüsse (m^3/s):	2018	1981-2010
Ktn Zuflüsse MQ:	78,72	72,62
Ktn Abflüsse MQ:	300,3	248,8
Ktn Gebietsabfluss MQ:	221,6	176,2

Grenze Slo/Drau:	2018	1981-2010
NQt (m^3/s):		51
HQ (m^3/s):	1600	1672

$HQ_{100} = 2800\ m^3/s$

Ktn-Zuflüsse: Drau (Osttirol), Gail, Gailitz, Olsa, Görtschitz, Lavant **Ktn-Abflüsse:** Drau, Möll KW Kaprun

Δ - Bilanz Modell- u. Datenunschärfe bzw. Wasserzwischenspeicherung (- aus Vorjahr; + fürs nächste Jahr)

Wasserbilanz von Kärnten

Überblick der letzten Jahre

HYDRO grafic Kärnten ... am Puls des Wassers.

Vergleichsperiode (Werte in mm):

	Niederschlag	Verdunstung	Abfluss	ZW-Speicher / Unschärfe
1981 - 2010	1198	582	592	23

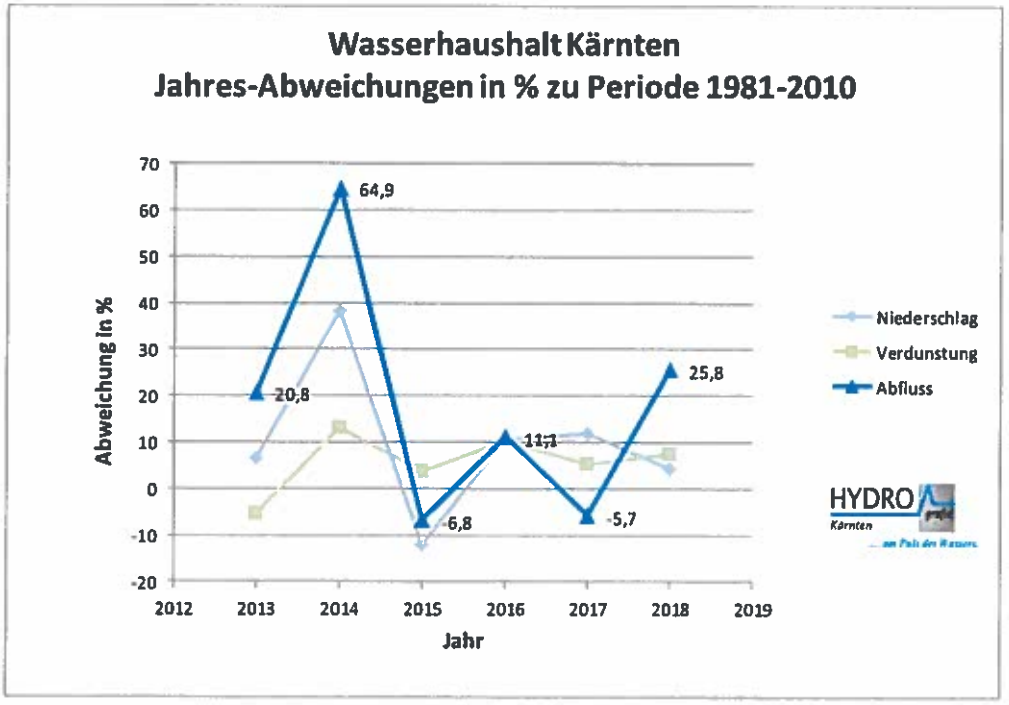
Einzeljahre (Werte in mm)

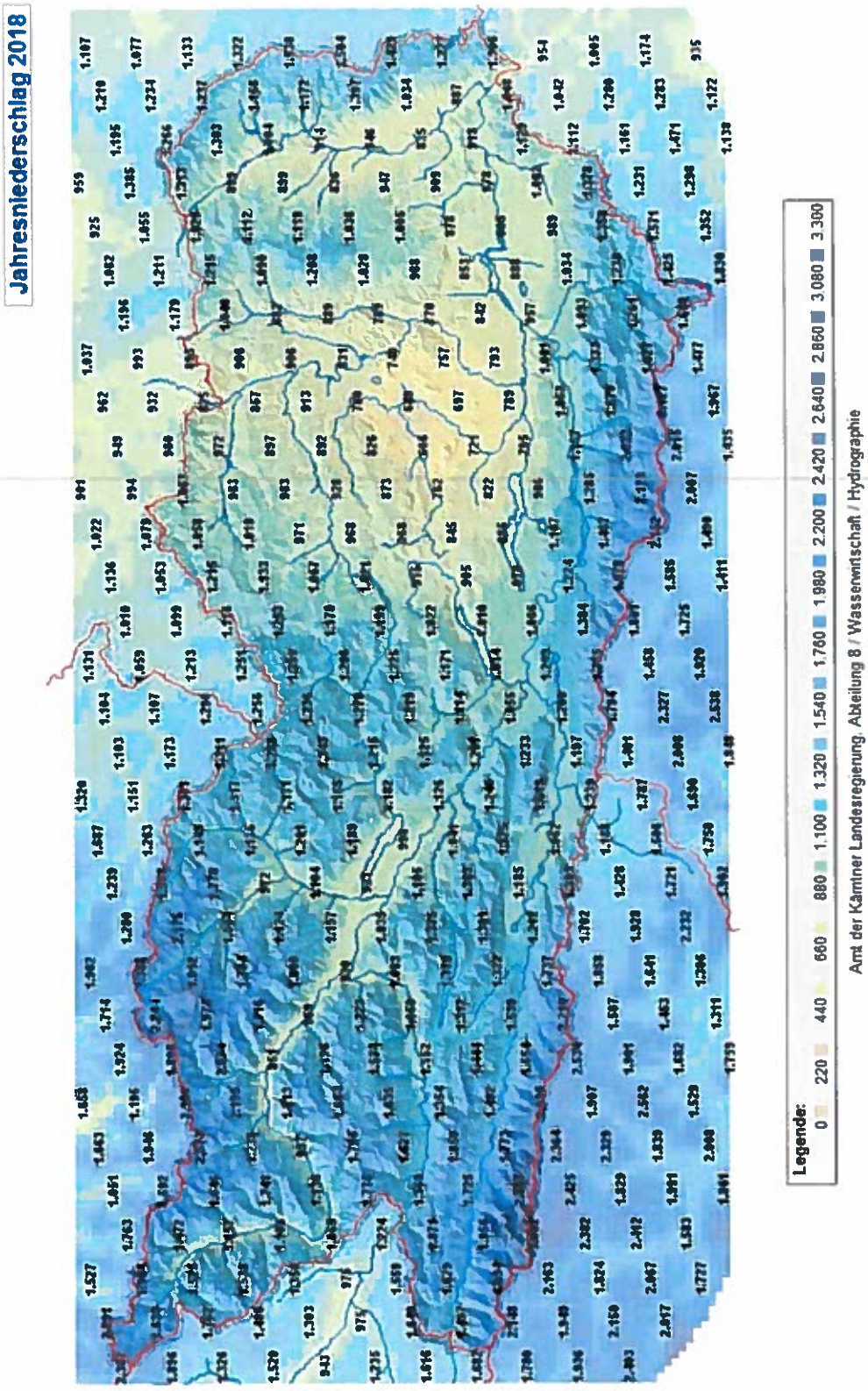
Jahr	Niederschlag	Verdunstung	Abfluss	ZW-Speicher / Unschärfe
2013	1278	550	715	13
2014	1655	658	976	21
2015	1055	604	552	-101
2016	1326	642	658	26
2017	1340	612	558	170
2018	1250	625	744	-119

Anmerkung: Wasserzwischenspeicherung (- aus Vorjahr; + fürs nächste Jahr)

Vergleich zu 1981-2010 (Werte in Prozent %)

Jahr	Niederschlag	Verdunstung	Abfluss
2013	6,7	-5,5	20,8
2014	38,1	13,1	64,9
2015	-11,9	3,8	-6,8
2016	10,7	10,3	11,1
2017	11,9	5,2	-5,7
2018	4,3	7,4	25,8




Jahresniederschlag 2018
Legende:
0 220 440 660 880 1.100 1.320 1.540 1.760 1.980 2.200 2.420 2.640 2.860 3.080 3.300
Amt der Kärntner Landesregierung, Abteilung 8 / Wasserwirtschaft / Hydrographie

2.6 Hydrological events

Flood event 28th to 31st of October 2018

Focus: Upper Drau- and Möll valley, Malta valley, Lower Drau valley, Upper Gail valley, Lower Drau, Eisenkappler Vellach

Warning / first measures:

Weather warnings for high precipitation sums and storms were published by the ZAMG a few days before the event. The warnings covered prognoses from 200 to 250 mm precipitation from Saturday, the 27th of October, to Tuesday, the 30th of October 2019. Moreover, probable peaks from 300 to 500 mm precipitation were predicted at the mountain barrier of the Carnic Alps.

After the first run of the flood forecasting model by the Hydrological Department of Carinthia, preliminary warnings were published online and via SMS for civil protection services.

Hydrological department of Carinthia, preliminary warning of Saturday, the 27th of October 2018:

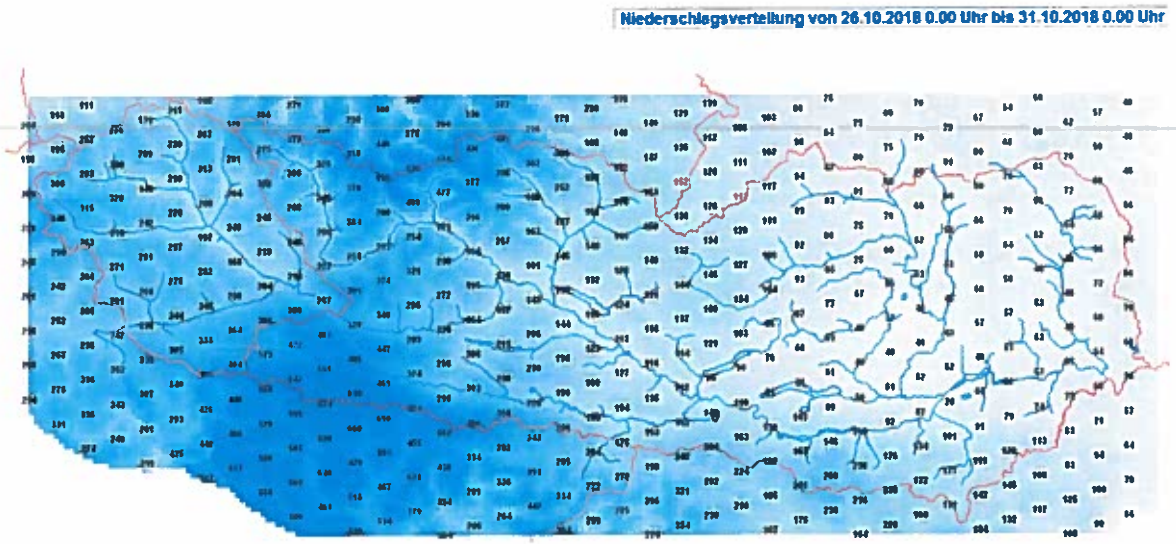
> Flood warning Carinthia – preliminary warning: rainfall distribution 27th – 30th October 2018: Gail valley and Upper Drau valley 200-230 mm, Upper Tauern 165 mm, other regions 30-100 mm. Snow line above 2000 m.
>
> High to very high flood discharges are expected at the Drau, Möll, Lieser and Gail River. The main focus is on Monday and Tuesday; Endangerment: Upper Drau, Upper Drau with Gail: High (up to HQ30) and very high (above HQ30); Gail, Möll: Medium (up to HQ10) and high (up to HQ30); Lieser, Vellach: Low (up to HQ5) and Medium (up to HQ10); Glan, Gurk, Lavant: Low (up to HQ5); Current information: www.wasser.ktn.gv.at/hydrographie

First debriefings of the federal crisis management group were hold two days before the event. The crisis management group included members of the district authorities of Hermagor, Spittal, Villach-Land, Klagenfurt-Land, Völkermarkt and Wolfsberg as well as the municipality of Villach. Both, the Hydrological Department of Carinthia and the Verbund AG, predicted a flood water runoff of a return period from 30 to 100 years (HQ30 to HQ100). For this reason, protection measures were ordered by the district authorities of Wolfsberg and Klagenfurt-Land. These included local protection measures and further lowering of reservoir-levels to reduce the peak discharge.

Dimensions of the flood event

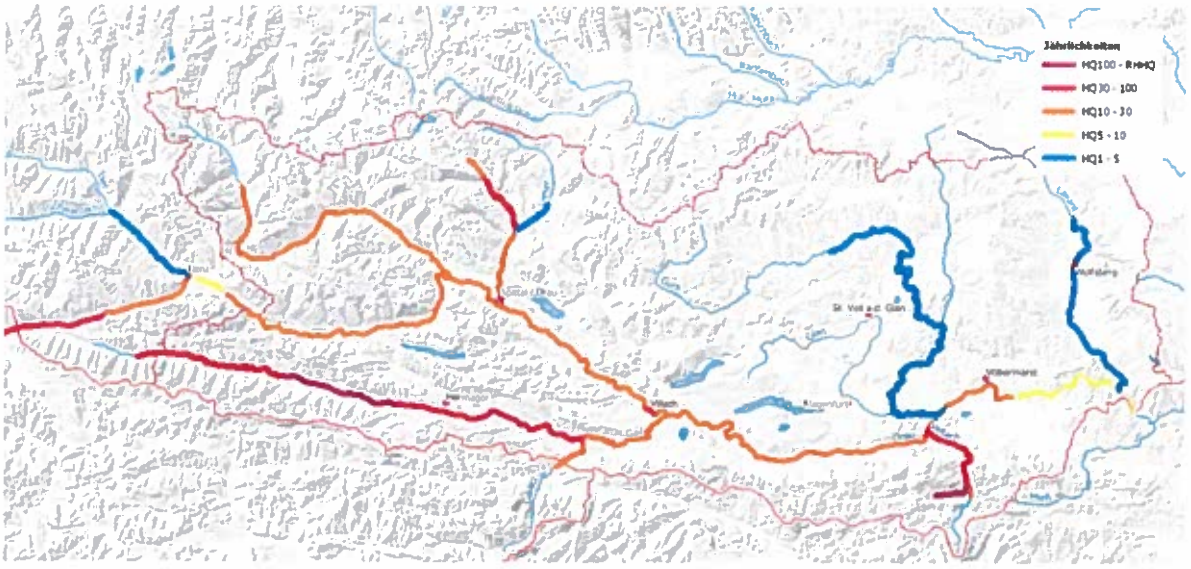
A flooding of Lavamünd could be prevented by controlling the outflow of reservoirs (hold up water volumes in reservoirs). Additionally, natural and artificial retention effects had a huge impact on the runoff. The peak discharge would have been much higher without these retention effects.

A dam break occurred at the Gail River near Rattendorf. This caused the inflow of water in direction to a ring dam at Rattendorf. After an overflow of this ring dam, the town was flooded. Floodings also occurred in Latschach at Velden through the Drau River. Storm damages were very high in Upper Carinthia, particularly in the Gail, Lesach- and Möll valley.



Picture 2.6.1: Precipitation sums HD Carinthia in consideration of wind effects (basis: station data, Kriging-Interpolation based on the altitude).

Hydrological data and facts concerning the flood event



Picture 2.6.2: Return periods of flood discharge (overview map)

Overview: Peak discharge at gauging stations. Estimation under consideration of (1) model results of Christian Kopeinig, (2) coordination with Verbund AG, (3) hydraulic calculations of IC Flussbau and (4) plausibility checks of discharges per unit area and water level to discharge ratios.

Drau:
Drau / Gauging station Oberdrauburg: 695 m^3/s ca. HQ_{22}
Drau / Gauging station Sachsenburg: 600 m^3/s ca. HQ_{11}
Drau / Gauging station Drauhofen 880 m^3/s ca. HQ_{10}
Drau / Gauging station Amlach-Spittal: 1120 m^3/s ca.HQ_{15}
Drau / Gauging station Villach: 1180 m^3/s ca. HQ_{15}
Drau / with Gail resp. KW Rosegg: 1850 $m^3/s \pm 70$ m^3/s ca. HQ_{26}
Drau / Gauging station Lavamünd Ort: reduced to 1550 - 1600 m^3/s; ca. HQ_7
(natural discharge, without reduction 2050 $m^3/s \pm 100$ m^3/s; ca. HQ_{24})

Möll:
Möll / Gauging station Winklern: 187 m^3/s ca. HQ_{20}
Möll / Gauging station Flattach: 300 m^3/s ca. HQ_{25} (reconstruction, impact of sediments)
Möll / Gauging station Möllbrücke: 395 m^3/s ca. HQ_{12}

Lieser:
Malta / Gauging station Sandriesen: 220 m^3/s ca. HQ_{30}
Lieser / Gauging station Fasan-Spittal: 300 m^3/s ca. HQ_{11}

Gail:
Gail / Gauging station Maria Luggau: 220 m^3/s ca. HQ_{60}
Gail / Gauging station Mauthen: 506 m^3/s ca. HQ_{55}
Gail / Gauging station Rattendorf: 680 m^3/s including runoff outside the river bed, estimated: 780 m^3/s (± 80 m^3/s uncertainty); HQ_{100} ; runoff at Waidegg (dam breakage), estimated ca. 800 m^3/s (± 50 m^3/s uncertainty); HQ_{115}
Gail / Gauging station Hermagor: 690 m^3/s ca. HQ_{45} (with retention)
Gail / Gauging station Nötsch 490 m^3/s ca. HQ_{30} (with retention)
Gailitz / Gauging station Thörl 220 m^3/s ca. HQ_{11}
Gail / Gauging station Federaun 640 m^3/s ca. HQ_{12}

Karawankenbäche:
Kappler Vellach / Gauging station Miklauzhof 270 m^3/s ca. HQ50
Ebriachbach / Gauging station Bad Eisenkappel 155 m^3/s ca. HQ120

Uncertainty range of peak discharges: up to ± 10 %

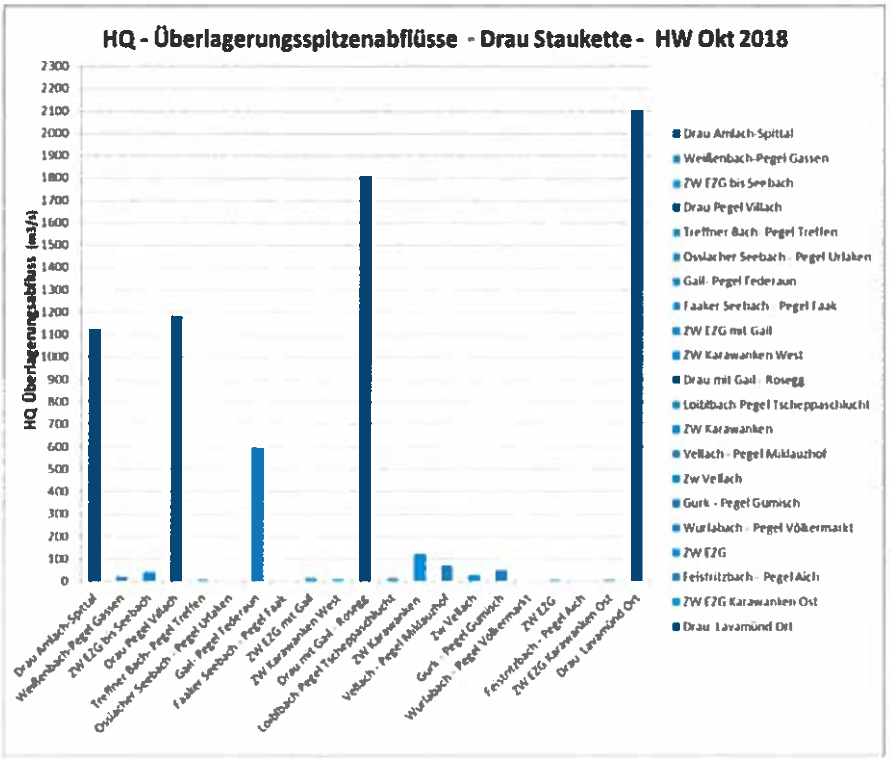
Estimation of tributaries

Valentinbach: 110 m^3/s; HQ30 (Schober/Koboltschnig, Schutzwasserwirtschaft)
Diebsbach: 24 m^3/s including sediments from debris flows; HQ100 (Kulterer, WLV)
Raggabach: HQ100 including sediments from debris flows; (Kulterer, WLV)

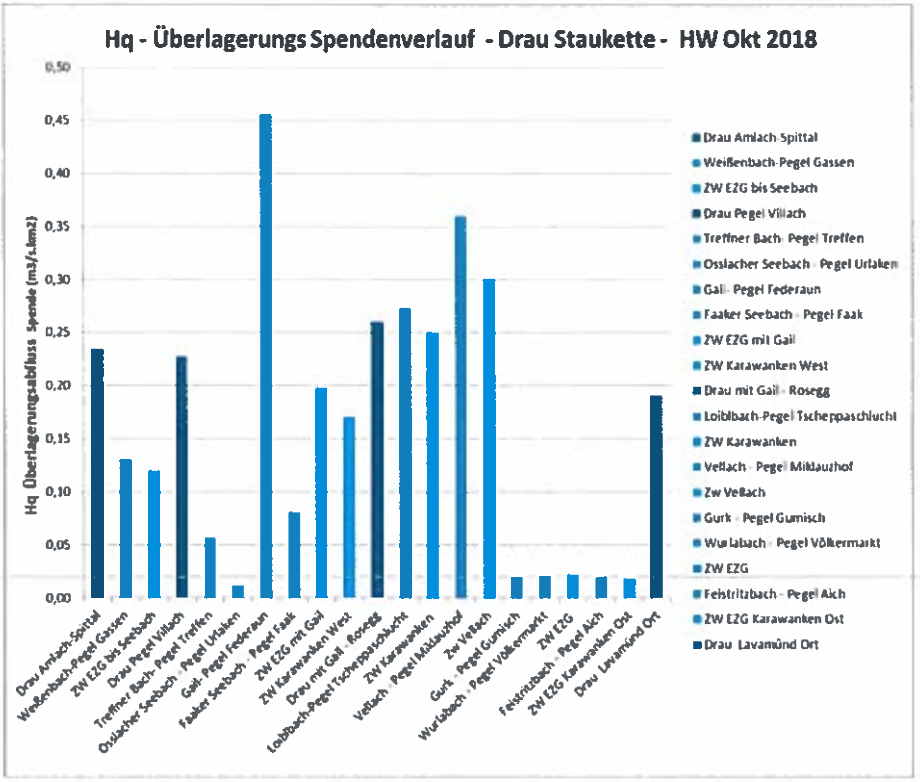
Analysis / Estimations:

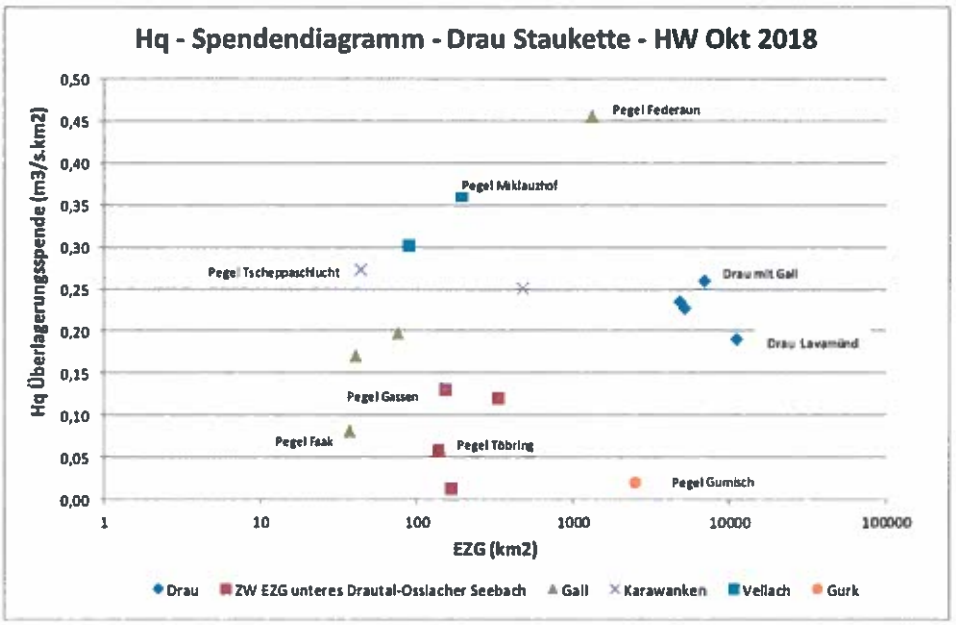
Abschätzung / Plausibilisierung der natürlichen HQ-Abflüsse
UNTERE DRAU HW 28-31.10.2018 (ohne Rückhalt durch Speicherbecken)
anhand von Hq - Überlagerungsspenden

Spitzenzuflüsse HQs (m3/s)		HQs	HQ überlag	Hqs	Hqüberl.	E (km2)	Ew(Summe)	HQs üb Sum
Drau Amlach-Spittal	Pegel Amlach	1120	1120	0,23	0,23	4779,6	4705	1120
Weißenbach-Pegel Gassen	Pegel Gassen	28	20	0,18	0,13	153,4	4858,4	1140
ZW EZG bis Seebach	Spende Gassen	60	40	0,18	0,12	333,6	5192	1180
Drau Pegel Villach	Pegel Villach	1180	1180	0,23	0,23	5192	5192	1180
Treffner Bach- Pegel Treffen	Pegel Töbring	18	8	0,13	0,06	140,5	5332,5	1188
Ossiacher Seebach - Pegel Urlaken	Pegel Urlaken	2	2	0,01	0,01	169,7	5502,2	1190
Gail - Pegel Federaun	Pegel Federaun	640	595	0,49	0,46	1304,9	6807,1	1785
Faaker Seebach - Pegel Faak	Pegel Faak	4	3	0,11	0,08	37,1	6844,2	1788
ZW EZG mit Gail	Spende Faaker Seebac	25	15	0,33	0,20	75,8	6920	1803
ZW Karawanken West	Spende Faaker Seebac	10	7	0,24	0,17	41	6961	1810
Drau mit Gail - Rosegg	KW Rosegg	1810	1810	0,26	0,26	6961	6961	1810
Loibibach-Pegel Tscheppaschlucht	Pegel Tscheppaschluch	24	12	0,55	0,27	44	7005	1822
ZW Karawanken	Spende Tscheppaschlu	250	118	0,53	0,25	471	7476	1940
Vellach - Pegel Miklauzhof	Pegel Miklauzhof	270	70	1,39	0,36	194,3	7670,3	2010
Zw Vellach	Spende Miklauzhof	125	27	1,39	0,30	89,7	7760	2037
Gurk - Pegel Gumisch	Pegel Gumisch	70	50	0,03	0,02	2555	10315	2087
Wurlabach - Pegel Völkermarkt	Pegel Völkermarkt	3	1	0,05	0,02	49,8	10364,8	2088
ZW EZG	Spende Wurlabach	11	5	0,05	0,02	224,2	10589	2093
Feistritzbach - Pegel Aich	Pegel Aich	4	2	0,04	0,02	101,3	10690,3	2095
ZW EZG Karawanken Ost	Spende Feistritzb	11	5	0,04	0,02	277,7	10968	2100
Drau Lavamünd Ort	Pegel Lavamünd	2100	2100	0,19	0,19	11042,6		2100

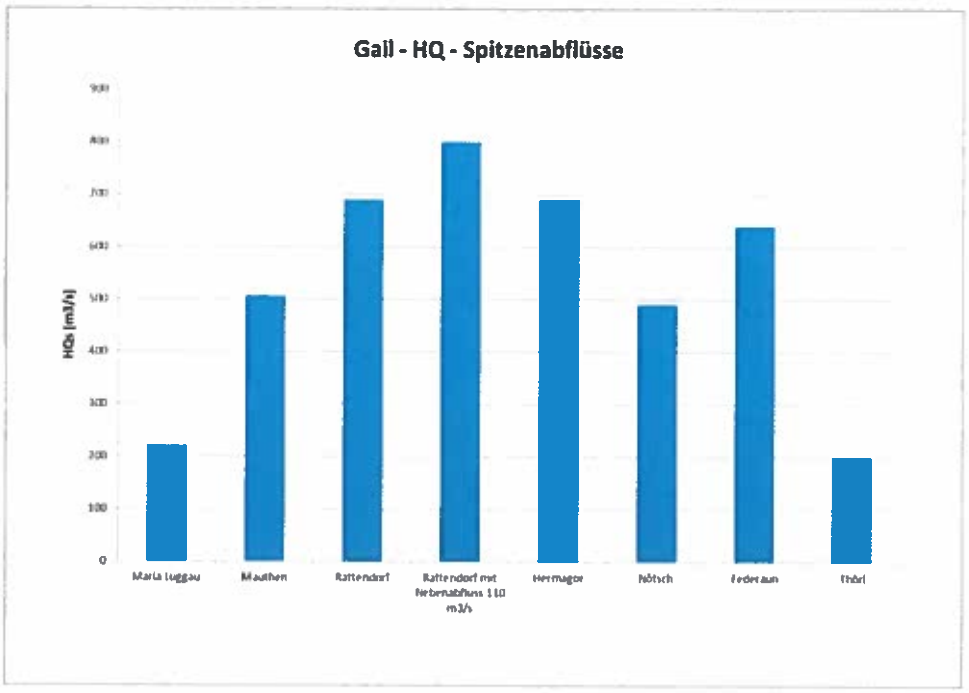


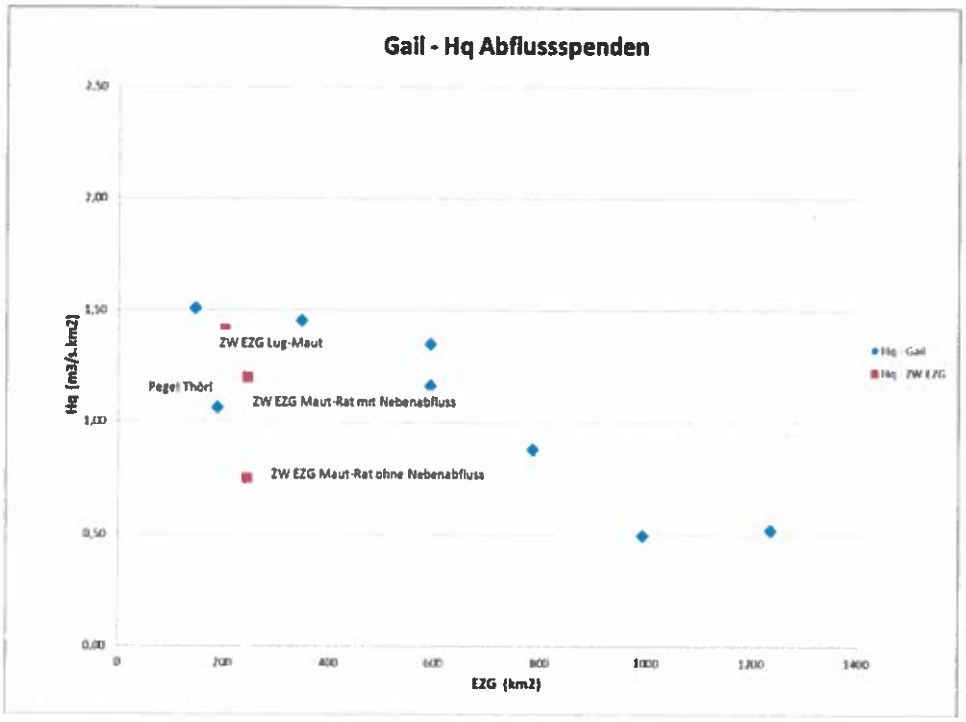
Picture 2.6.3: Cumulated peak discharges at the Drau River. Basis: analyses of peak discharges per unit area (Hq) of gauging stations (natural discharge, without retention measures)





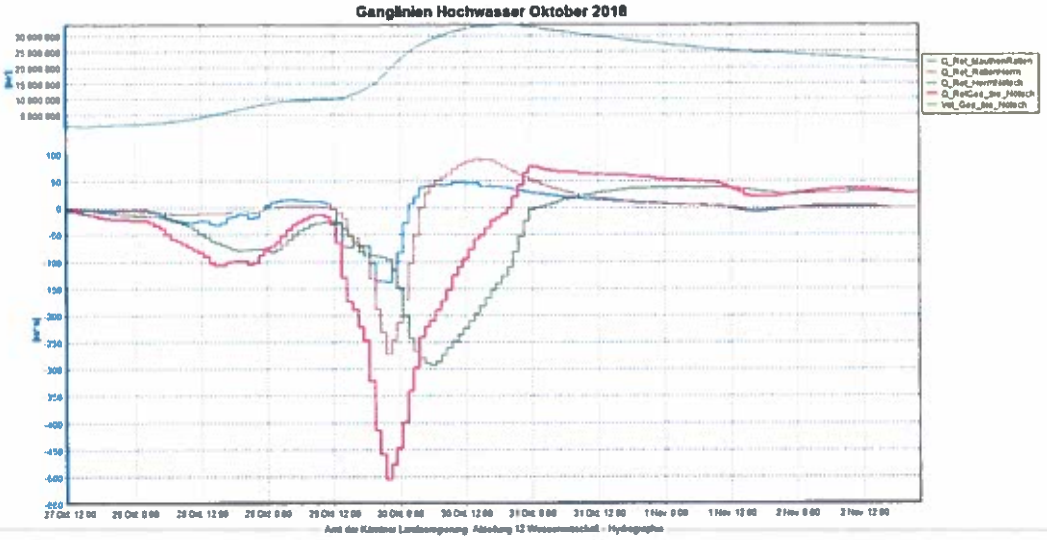
Picture 2.6.4: Estimation / plausibility checks via cumulated peak discharges per unit area (Hq) at the Drau River (natural discharge, without retention)



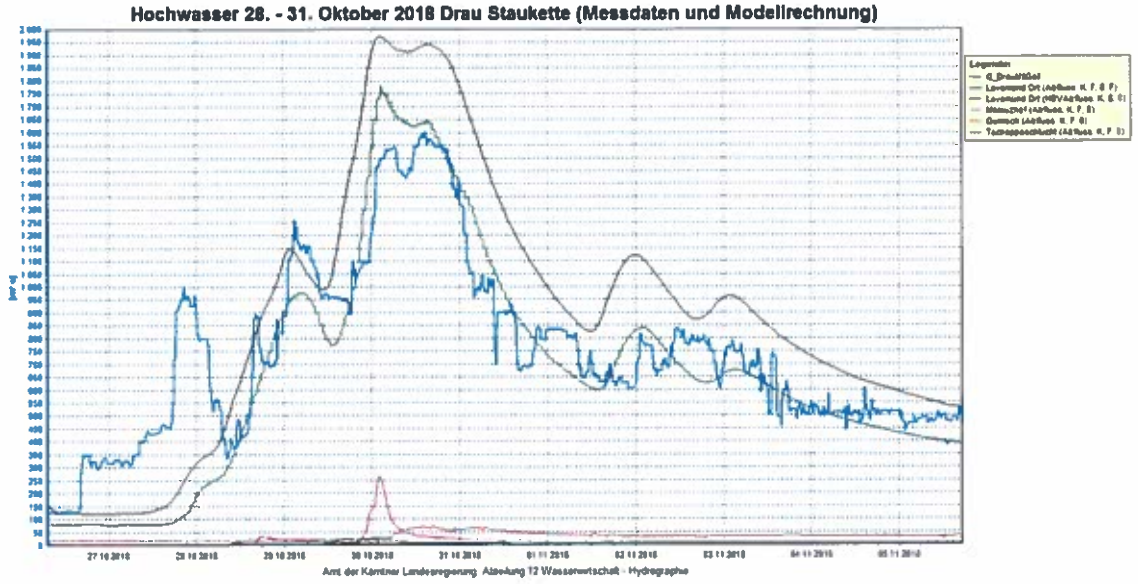


Picture 2.6.5: Estimation / plausibility checks at the Gail river – HQ peak discharges and Hq peak discharges per unit area.

Retention effects at the Gail River from Mauthen to Nötsch and model results for Lavamünd



Picture 2.6.6: Reduction of the flood wave and retention volume in the Gail valley from Mauthen to Nötsch by using intended retention areas (model of the Hydrological Department of Carinthia, Christian Kopeinig, in cooperation with Schutzwasserwirschaft)



Picture 2.6.7: Flood wave in Lavamünd. Model of the Hydrological Department of Carinthia (Christian Kopeinig). Inflow to the storage chain at Rosegg (most probable value **1850 m³/s** ± 70 m³/s and outflow at Lavamünd (without reduction in the storage chain). HQ Model = 1970 m³/s; HQ plausibility check of peak discharges per unit area = 2100 m³/s (picture 2.6.3). These values represent the approximated range of variation of the Hydrological Department of Carinthia, if no influence of hydrologic power plants is given. Therefore, the approximated most probable value is **2050 m³/s** (± 100 m³ / s).

Photos (BMI – Helicopter / Koboltschnig): Drau

Photo 1: Drau in direction to Oberdrauburg

Photo 2: Drau at Hauzendorf

Photo 3: Drau at Greifenburg

Photo 4: Drau at Kleblach-Lind

Photo 5: Drau at Amlach / Spittal

Photo 6: Drau at Villach

Photo 7: Drau at Latschach / Velden

Photo 8: Drau at hydrological power plant Ferlach (Verbund AG)

Photos: Möll

Photo 9: Möll at Lainach

Photo 10: Landslide at Rangersdorf

Photos: Gail

Photo 11: Gail in Kötschach-Mauthen (flood protection measures for HQ100)

Foto 12: Gail at Rattendorf

Photo 13: Gail at Jenig

Photo 14: Gail at Waidegg

Photo 15: Gail at Tröpolach (old railway line)

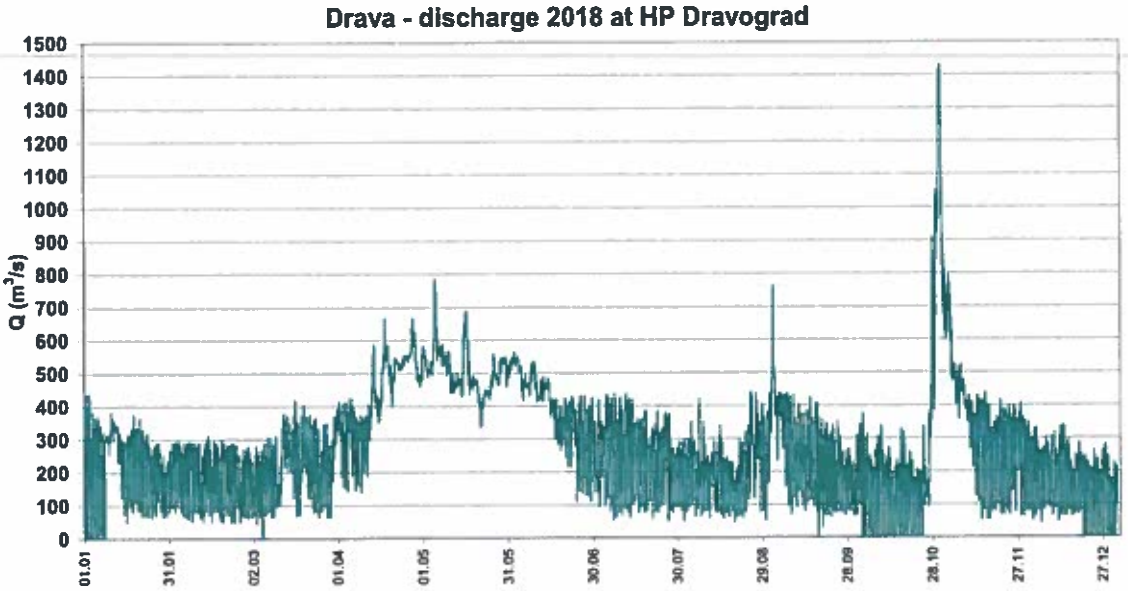
Photo 16: Gail at retention basin Möderndorf

Photo 17: Gail at hydrological power plant Schütt (current construction site)

Photo 18: Gail at Villach (Infineon)

3 DATA - SLOVENIAN ENVIRONMENT AGENCY (ARSO)

3.1 Discharges 2018 for the Drava River: hydropower plant (HP) Dravograd



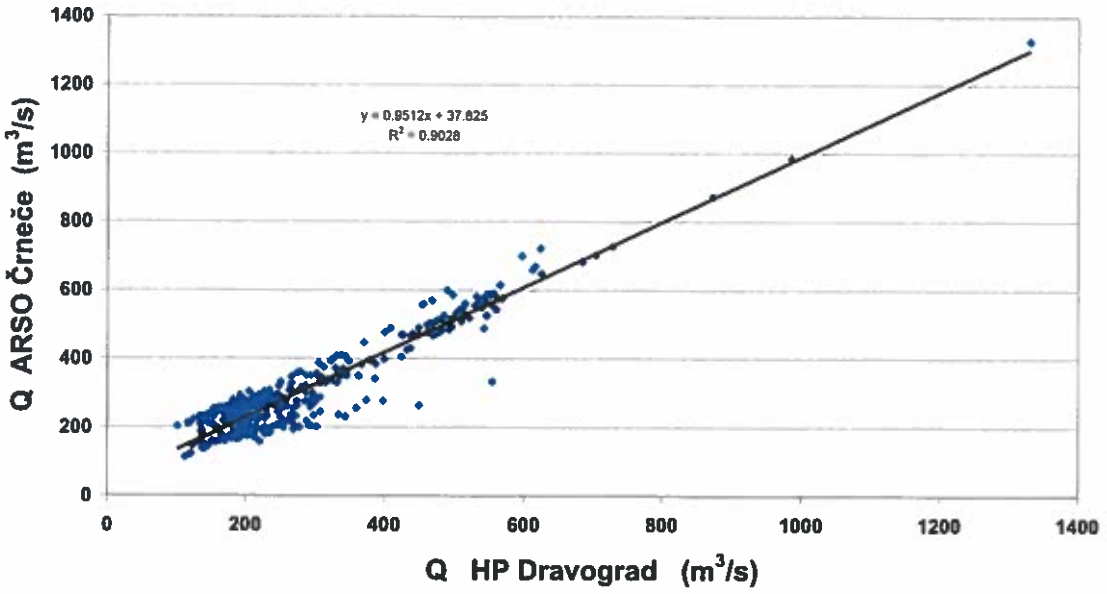
Hydropower plant Dravograd on the Drava River:

Mean value discharge 2018 : MQ = 290 m^3/s

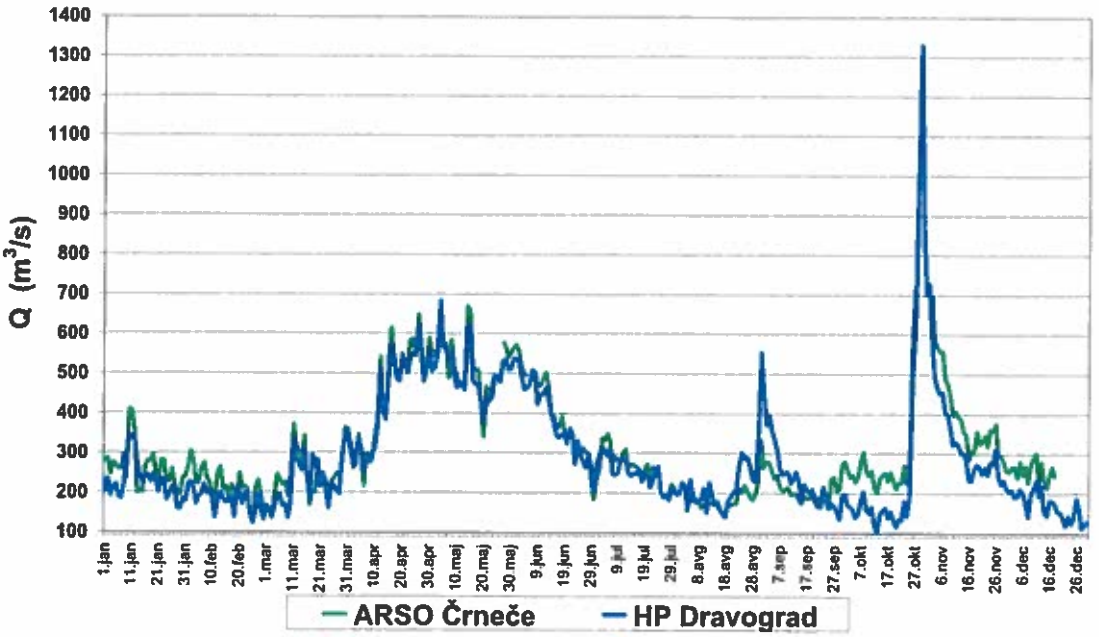
Highest discharge 30.10.2018: HQ = 1430 m^3/s

Correlation between mean velocity measured with fixed ADCP and mean velocity measured with ADCP on boat (hydrometric measurement) at gauging station Črneče is not very good.

Due to the poor correlation between measured velocities, the correlation between discharges on hydropower plant (HP) Dravograd and gauging station Črneče is not optimal:



Drava - discharge 2018 at g.s. Črneče and HP Dravograd



4 ATTENDANCE LIST

5th meeting of the subgroup for Hydrology for the Drava River
Working group "Water Management", Drava Commission

Ljubljana, 13 March 2019

ATTENDANCE LIST

Name	Organization	Signature
JANEZ POLAJNAR	ARSO	
Karl Hans Ogertschnig	VERBUND	
Elisabeth GUTSCHI	HD Kärnten	
Johannes Moser	HD Kärnten	
CHRISTIAN KOFELNIG	— " —	
ANDREJ GOLOB	ARSO	
FLORJANA ULAGA	ARSO	
ROMAN TRČEK	ARSO	
Sašo Kreslin	DEM	
MIRA KOBOLD	ARSO	
BOGDAN LALIĆ	ARSO	