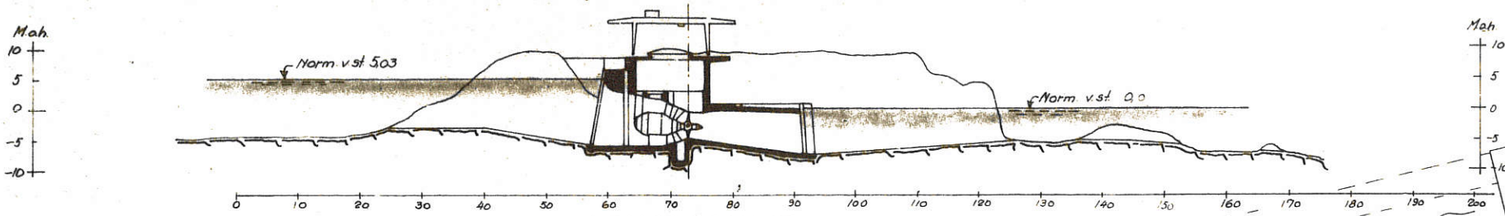
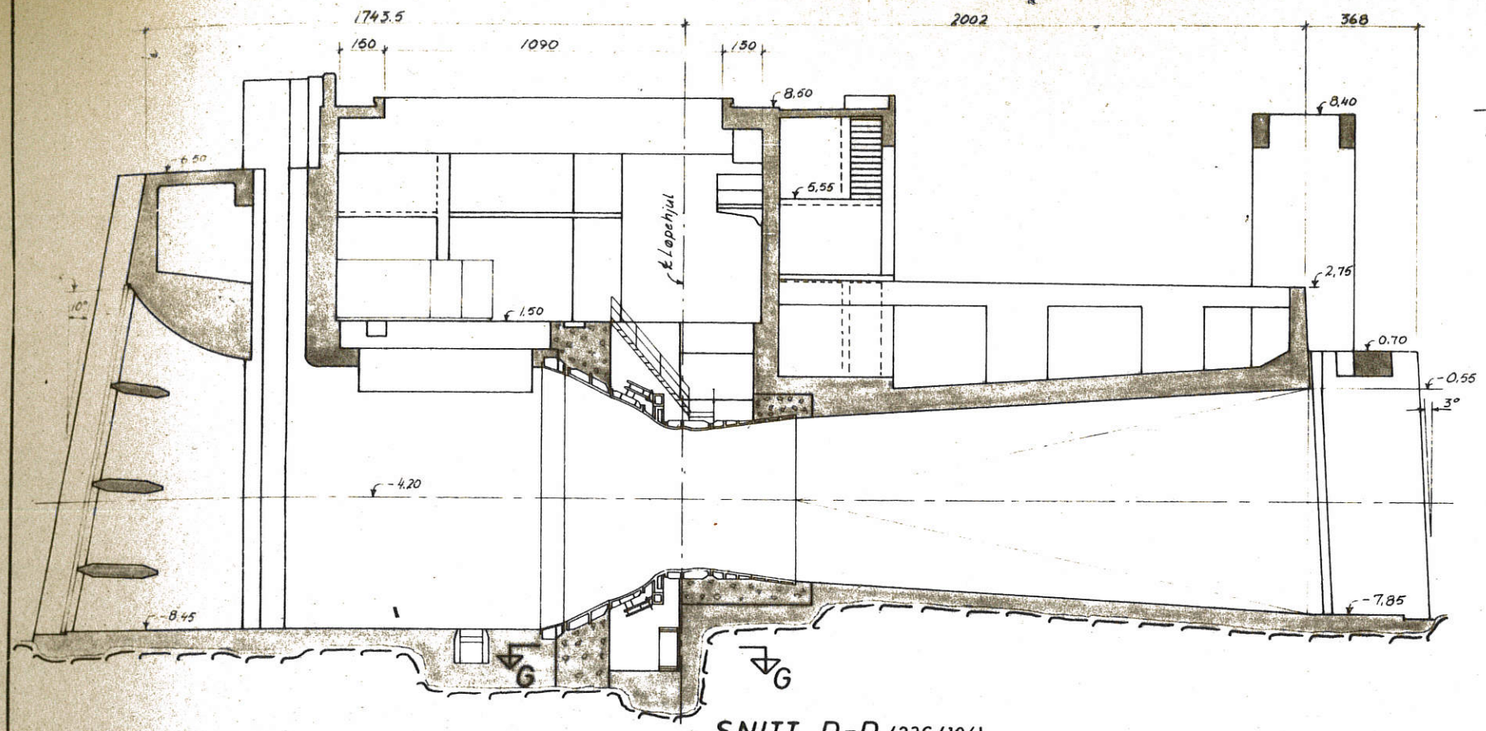
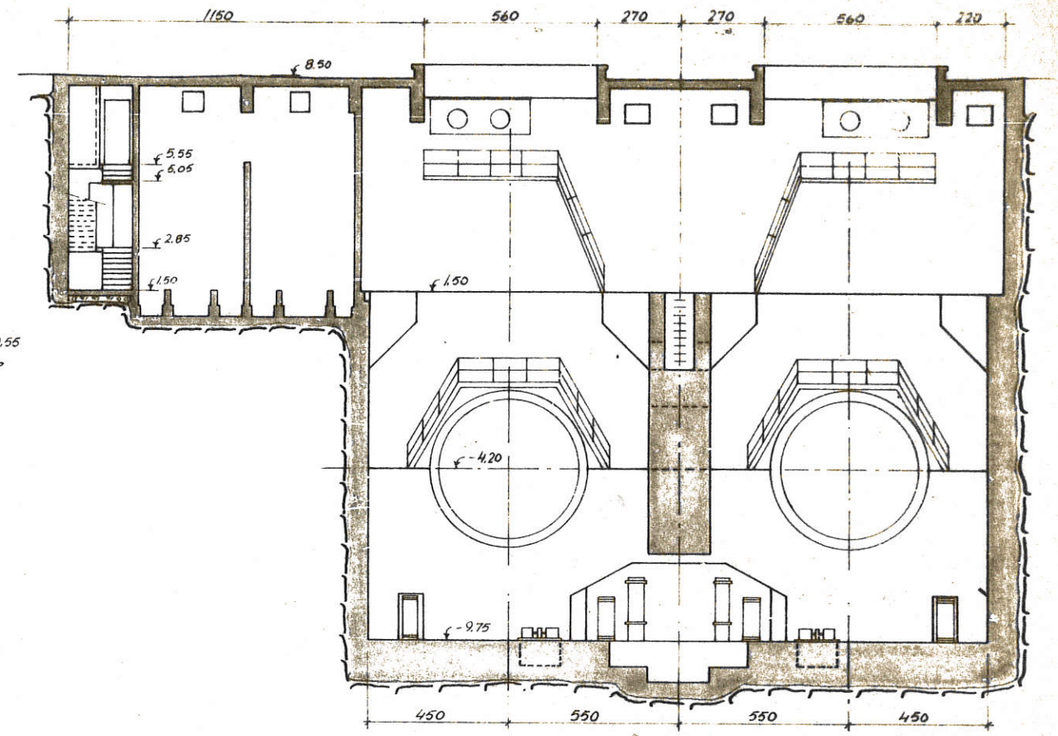


LENGDESNITT

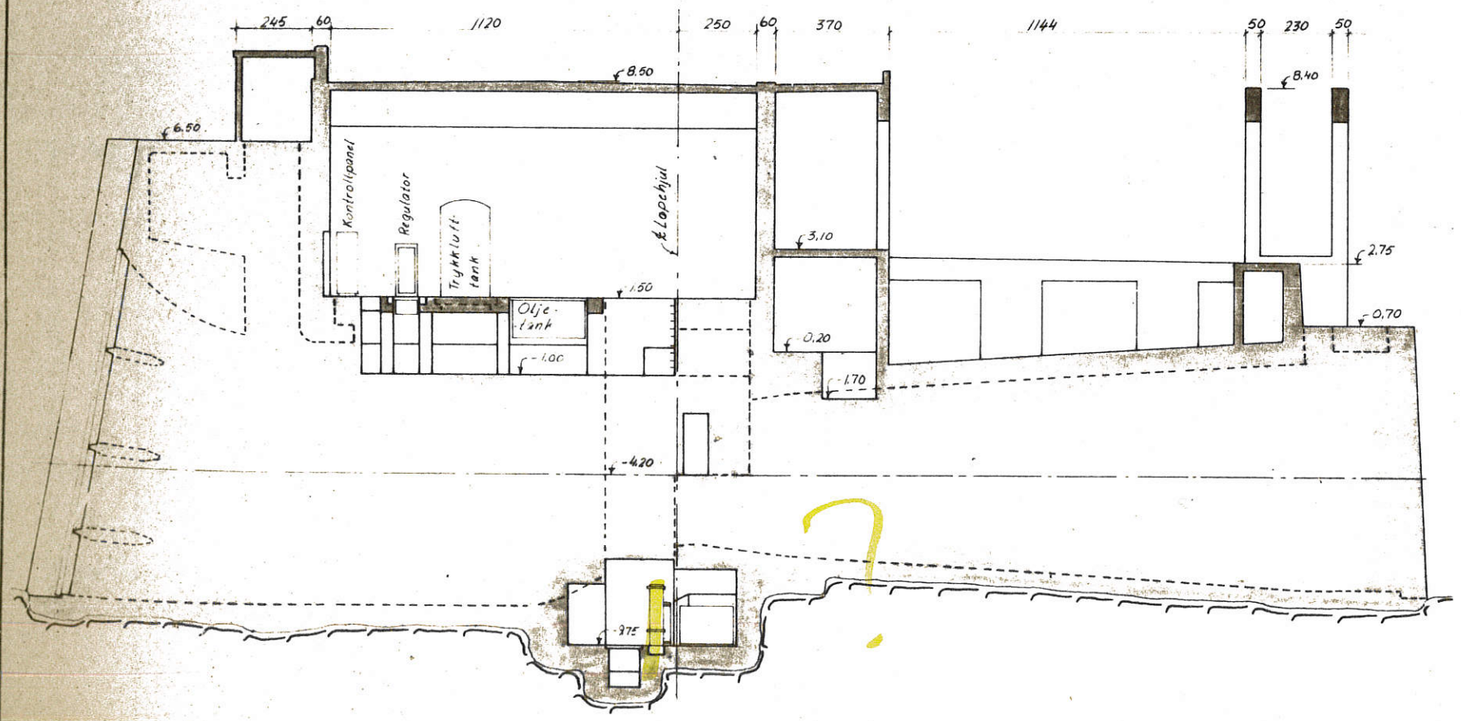
UNION BRUK	
KLOSTERFOSS KRAFTVERK NYTT KRAFTVERK ALT. MED KLAPPER I DAM SITUASJONSPLAN.	Målestokk 1:500 (som vist) · Tegn. 15/5-67 · Trac. · Kfr. · Erstatning for:
SIVILINGENIØR ELLIOT STRØMME A/S RÅDGIVENDE INGENIØRER M.R.I.F.	236/067 · Erstattet av:



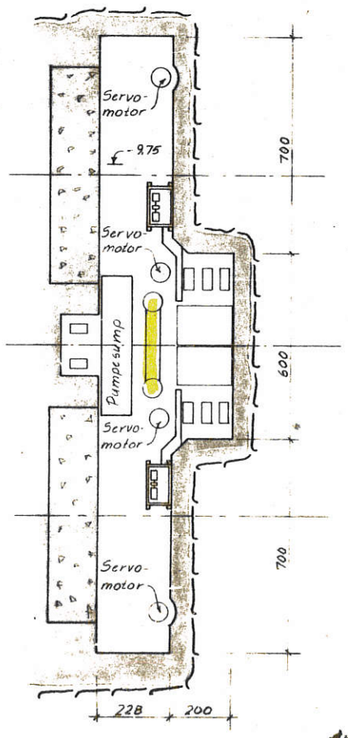
SNITT D-D (236/104)



SNITT F-F (236/104)



SNITT E-E (236/104)



SNITT G-G

Anm.:
For plassering av snittene se tegn. 236/104

Rev. B 23/4-70 LL Tegningen ajourført og omredigert
Erstatter tegn. 236/101, 102, 103, 104A, 105A

UNION BRUK

KLOSTERFOSS KRAFTVERK
KRAFTSTASJON
ARRANGEMENT
SNITT

1:100

Tegn. LL 22/4-70
Trac.
Kfr.

SIVILINGENIØR ELLIOT STRØMME A/S
RÅDGIVENDE INGENIØRER M.R.I.F.

236/105 B

Napisna plošča
Name plate
R.st./Drw. No.:1241197

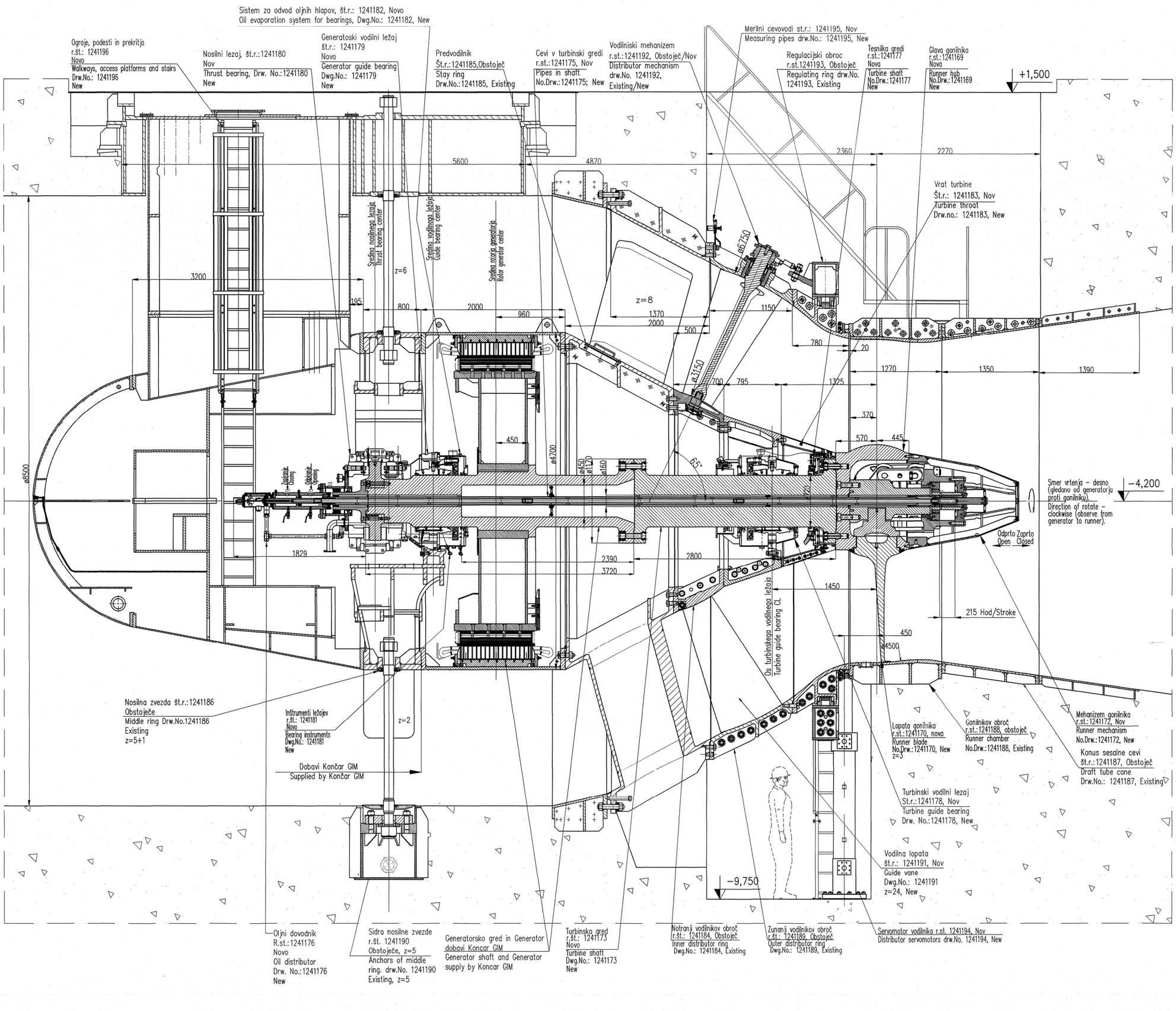
LITOSTROJPOWER

KLOSTERFOSS HPP, UNIT 1

Turbine type	CT3-4,5/1300
Rated output	7130 kW
Rated head	5,03 m
Rated discharge	160 m3/s
Rotational speed	100 1/min
Runaway speed	255 1/min

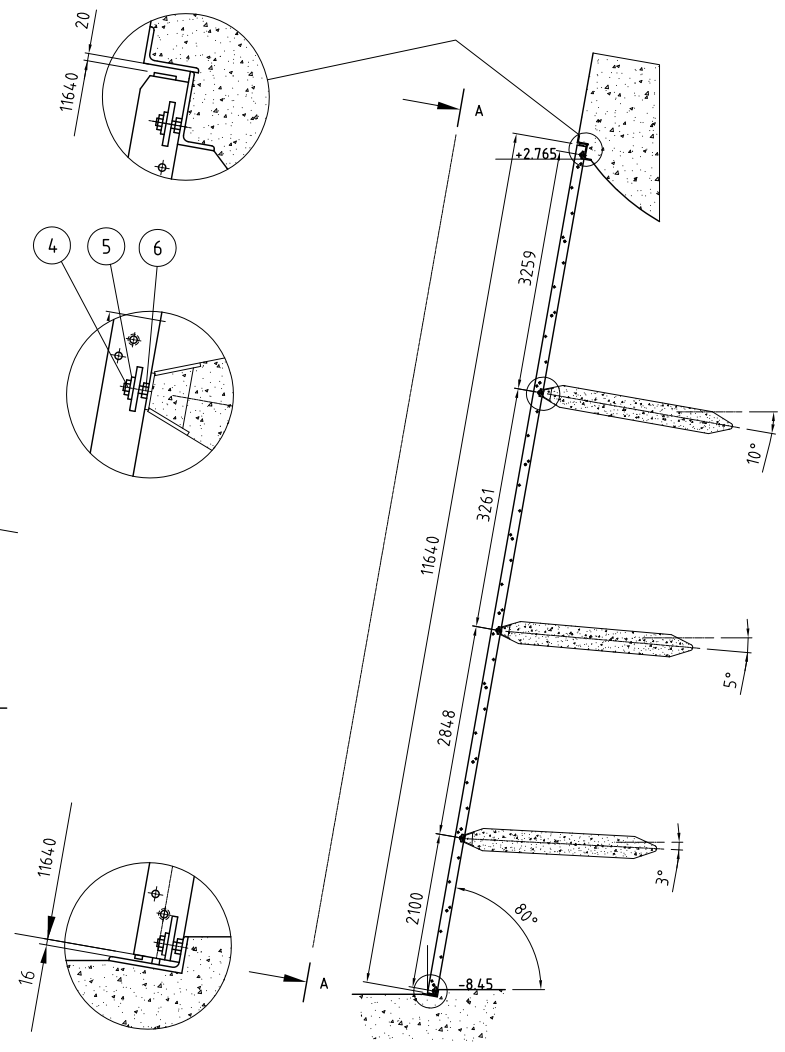
Made in Slovenia 2015 (E1-0798)

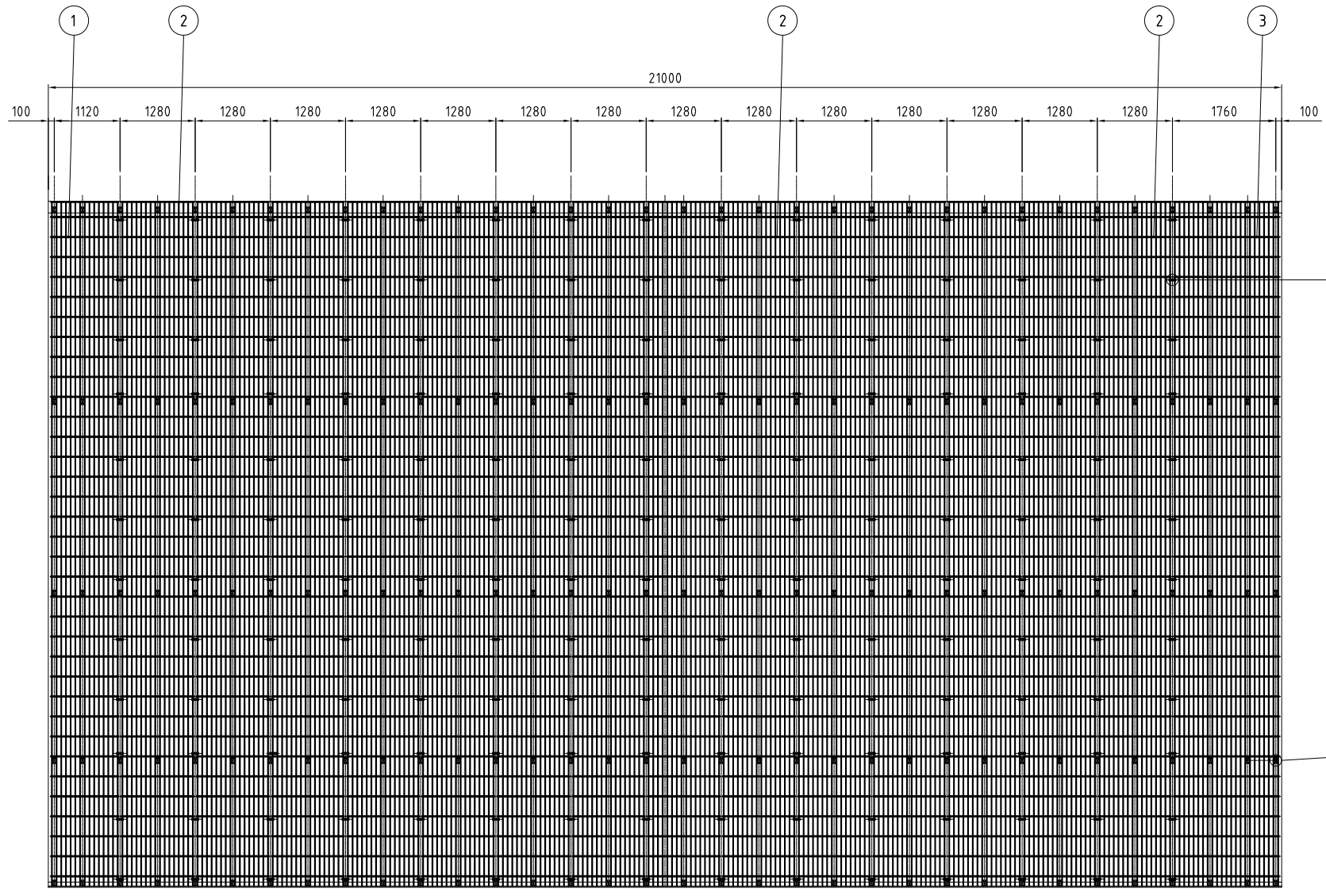
2016 za agregat 2
2016 for unit 2

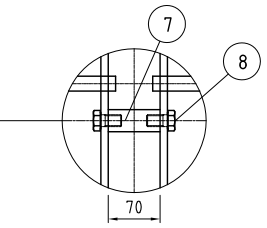


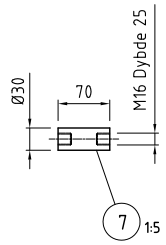
Revision	Datum/Datum	Opis/Description
Naročnik Besteller		Akershus Energi
		Skien Kraftpro
LITOSTROJPOWER		Objekt/Objekt: KLOSTERFO
		Št. naročila/Bestell-Nr.: E1-07
Izdelal Entworfen	31.01.2013	Aleš B.
Pregledal Geprüft	31.01.2013	M.Hrovat/M.Kržnar
Potrdil Bestätigt	31.01.2013	S.Cizelj
Oddelek Abteilung	Datum Datum	Ime Name / Podpis Unterschrift
Merilo Meßstab	1:25	Ime/Name: Turbine cross Prerez tur
05-065	Masa Masse /	Format Zeich. Format: A1
		Sprememba Revision
		St. rabe Zeich. Nr.: 1241

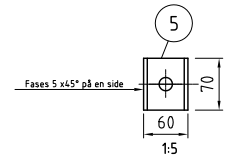
HRV +5.20

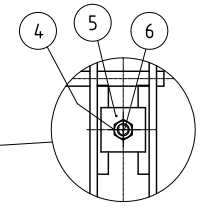












Sett: A-A

ANTALL QUANTITY	POS.NR. ITEM NO.	BESKRIVELSE/STANDARD DESCRIPTION/STANDARD	MATERIALE MATERIAL	VEKT WEIGHT	ANMERKNING DRAWING NO.
360	8	6-kt.skrue	M16x30	A2	-	-
180	7	Distanse	Ø30x70	165M	60	-
-	6	Skrue	Eksisterende	1	-	-
170	5	Skive	10x60x70	LXD 2101	50	-
-	4	Mutter	Eksisterende	-	-	-
1	3	Høyre sidepanel	Tegn. 103079	R.fritt	2845	-
14	2	Midtpanel	Tegn.103080	R.fri	26650	-
1	1	Venstre sidepanel	Tegn.103079	R.fritt	1855	-

Kunde: Klosterfossen Kraftverk, Skien
Anlegg: Inntak
Ordrenr.: 3561
Index: -

Dato: 22.01.14 | Tegn./Konstr.: AT | Godkjent: ØK. | Skala: 1:50

LYSAKER & THORRUD AS
Mekanisk verksted

Klosterfossen Kraftverk

Varegrind BxH= 2x10.5x11.65 13.65mVS
Arrangement

Erstatning for: jh | Erstattet av: hgg

103078 A

Henvisning: f | Beregning: f | Filnavn: sd

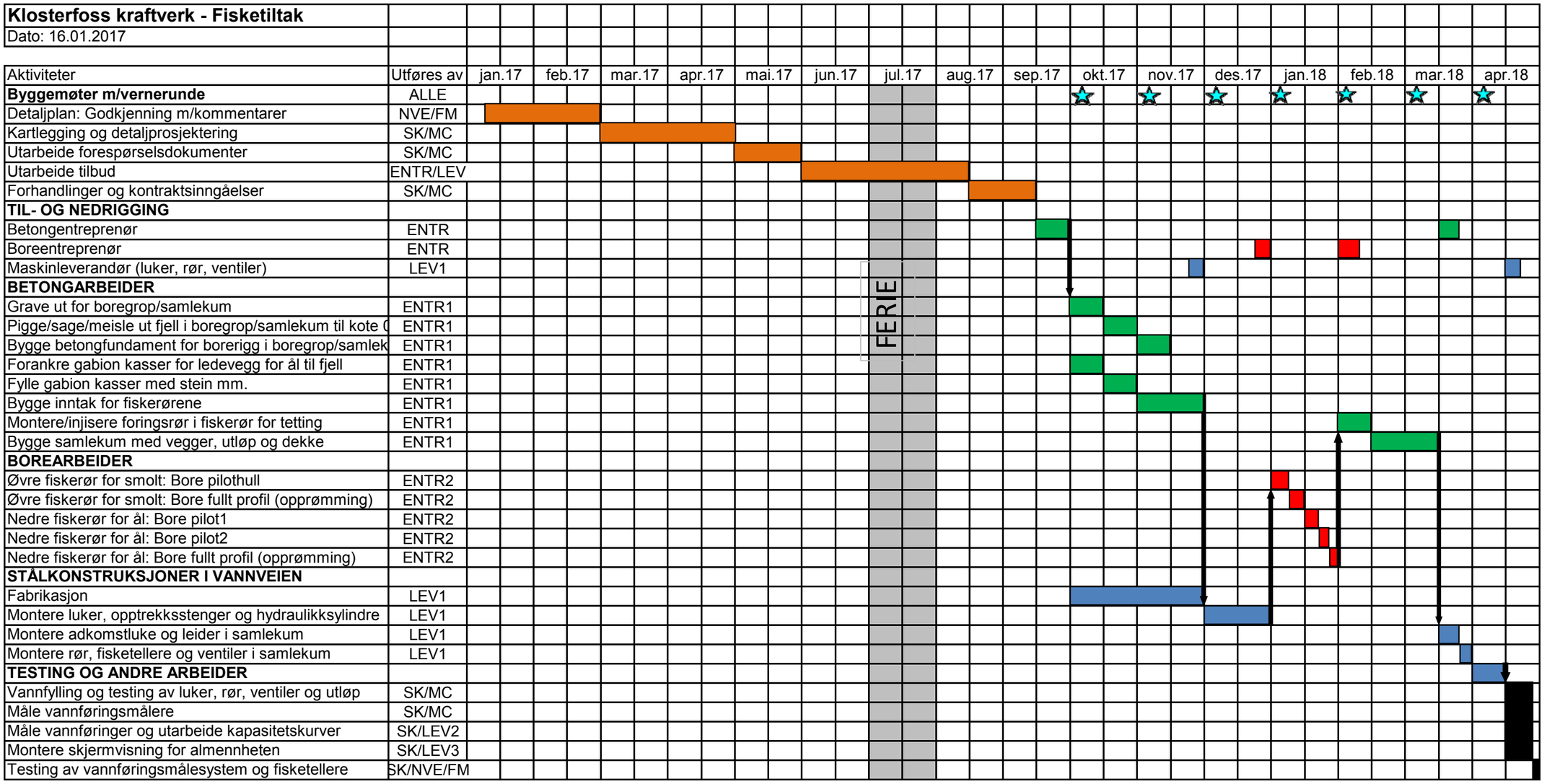
#	Date	Revision	Name
A	20.02.14	Endret pos 5	CJ

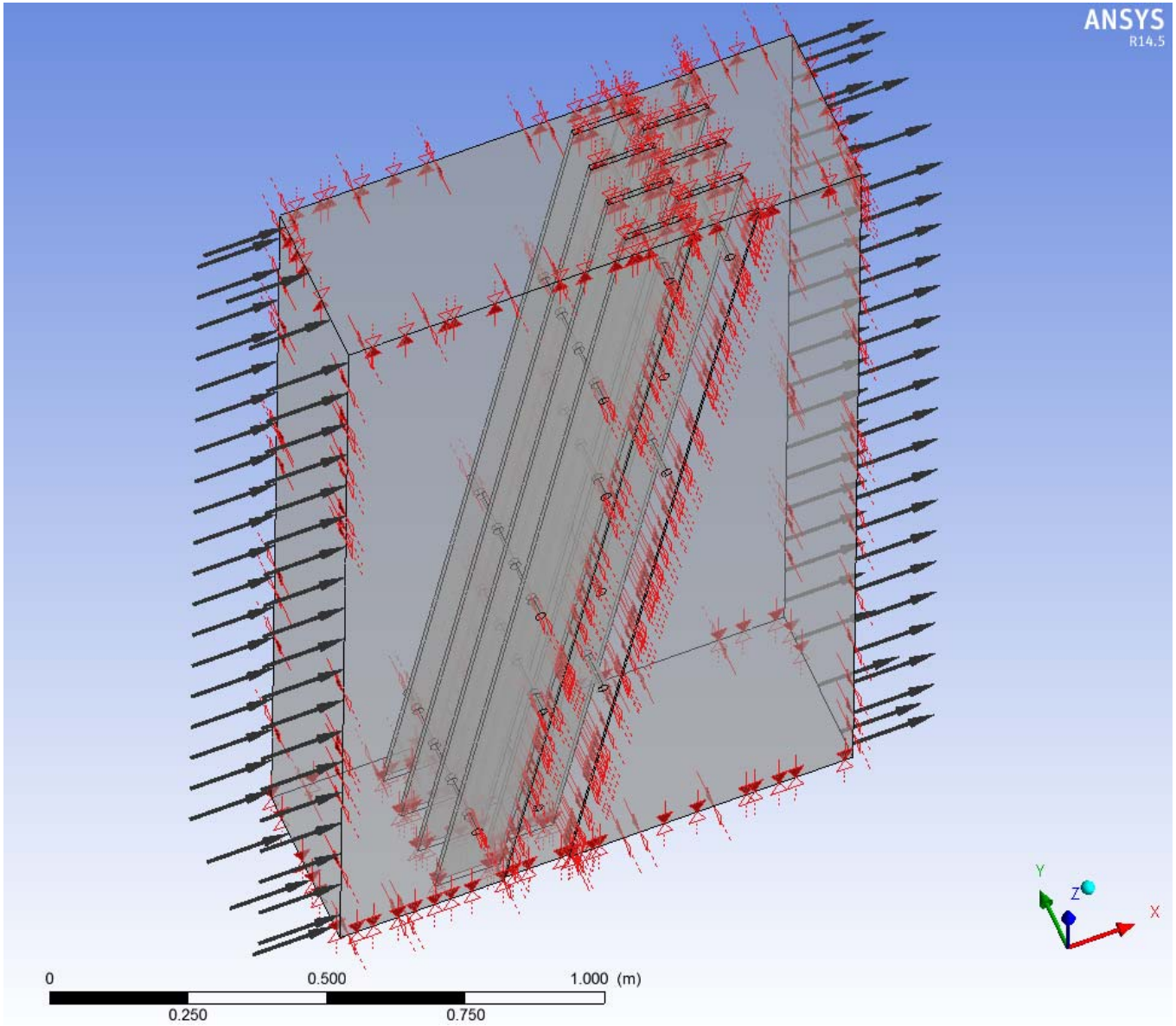
Tegn.nr. 100 - Fremdriftsplan for byggeperioden - Versjon 3

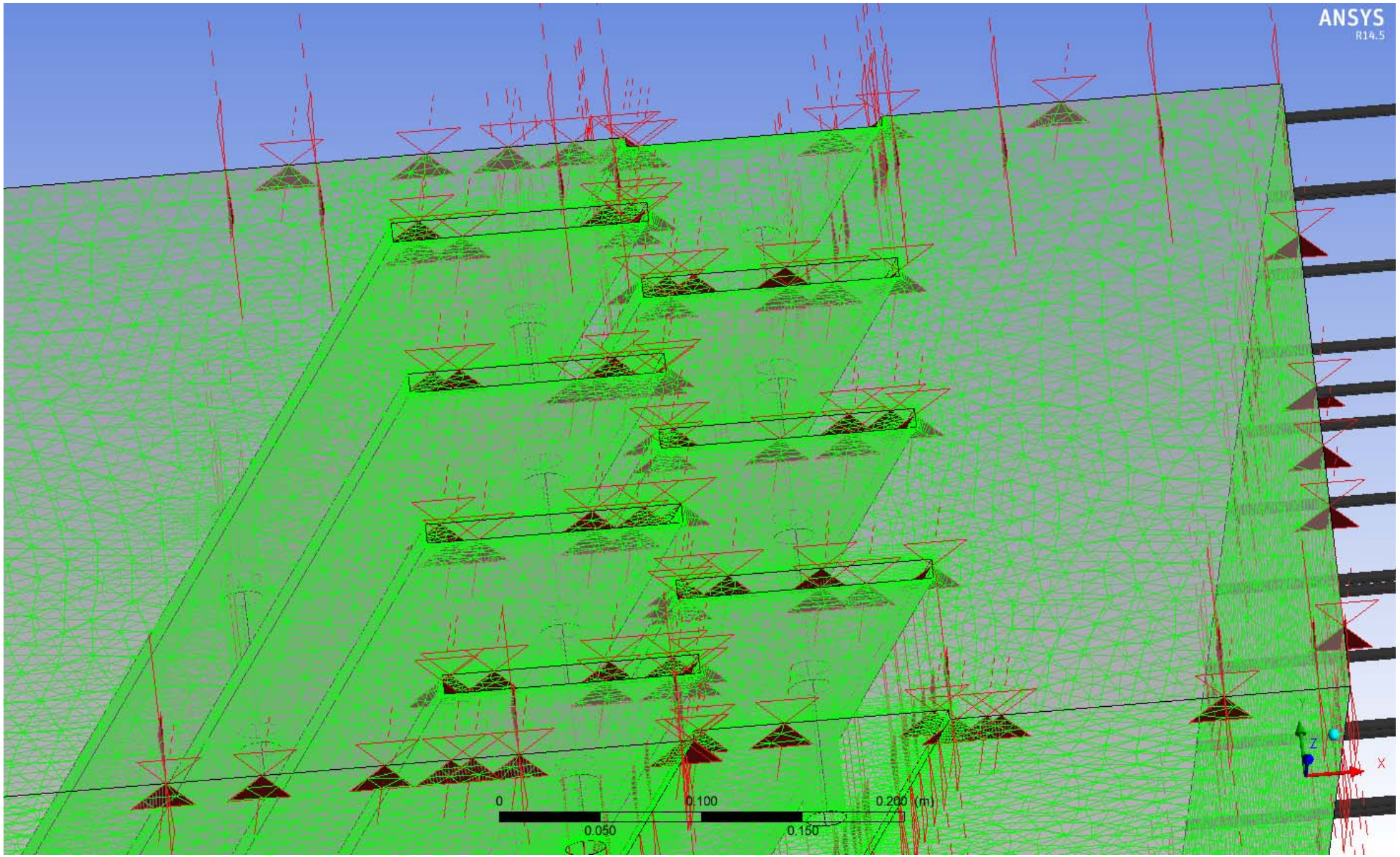
Klosterfoss kraftverk - Fisketiltak

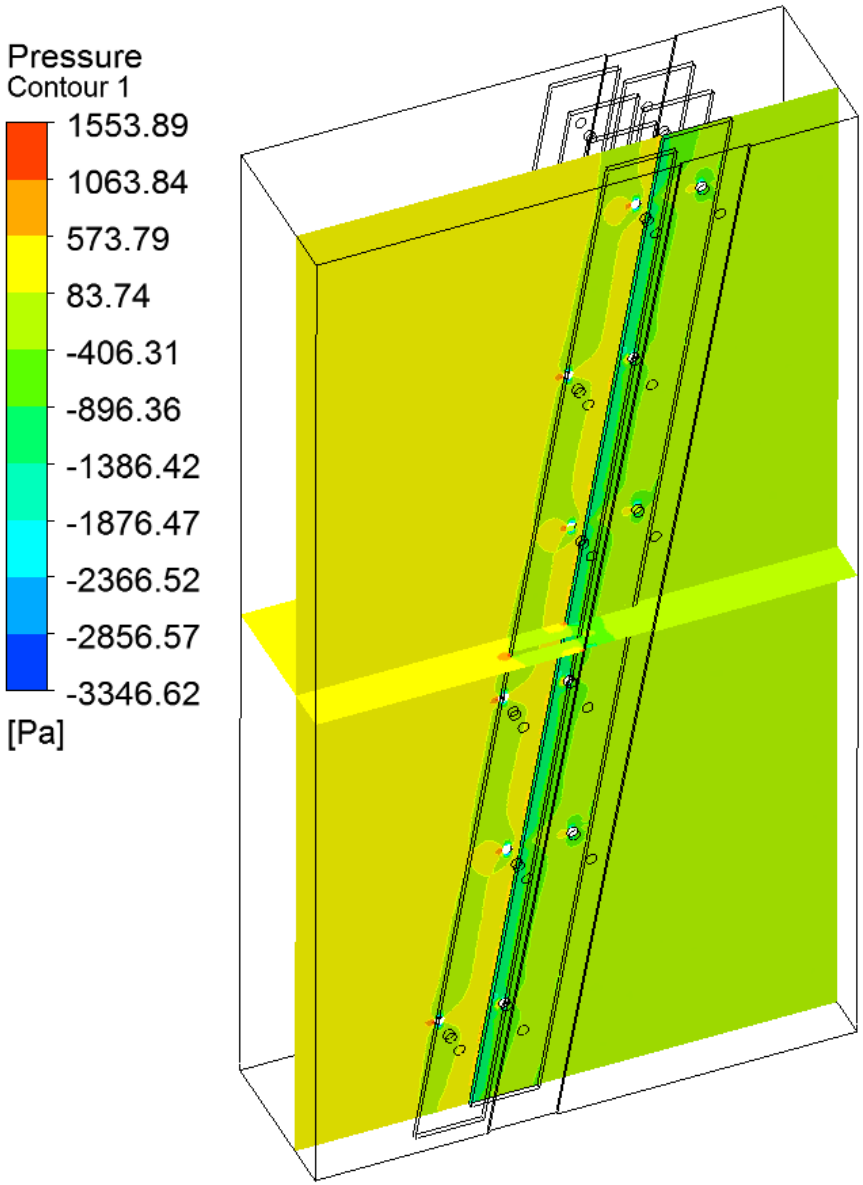
Dato: 16.01.2017

Aktiviteter	Utføres av
Byggemøter m/vernerunde	ALLE
Detaljplan: Godkjenning m/kommentarer	NVE/FM
Kartlegging og detaljprosjektering	SK/MC
Utarbeide forespørselsdokumenter	SK/MC
Utarbeide tilbud	ENTR/LEV
Forhandlinger og kontraktsinngåelser	SK/MC
TIL- OG NEDRIGGING	
Betongentreprenør	ENTR
Boreentreprenør	ENTR
Maskinleverandør (luker, rør, ventiler)	LEV1
BETONGARBEIDER	
Grave ut for boregrop/samlekum	ENTR1
Pigge/sage/meisle ut fjell i boregrop/samlekum til kote (	ENTR1
Bygge betongfundament for borerigg i boregrop/samlek	ENTR1
Forankre gabion kasser for ledevegg for ål til fjell	ENTR1
Fylle gabion kasser med stein mm.	ENTR1
Bygge inntak for fiskerørene	ENTR1
Montere/injisere foringsrør i fiskerør for tetting	ENTR1
Bygge samlekum med vegger, utløp og dekke	ENTR1
BOREARBEIDER	
Øvre fiskerør for smolt: Bore pilothull	ENTR2
Øvre fiskerør for smolt: Bore fullt profil (opprømming)	ENTR2
Nedre fiskerør for ål: Bore pilot1	ENTR2
Nedre fiskerør for ål: Bore pilot2	ENTR2
Nedre fiskerør for ål: Bore fullt profil (opprømming)	ENTR2
STÅLKONSTRUKSJONER I VANNVEIEN	
Fabrikasjon	LEV1
Montere luker, opptrekksstenger og hydraulikksylindre	LEV1
Montere adkomstluke og leider i samlekum	LEV1
Montere rør, fisketellere og ventiler i samlekum	LEV1
TESTING OG ANDRE ARBEIDER	
Vannfylling og testing av luker, rør, ventiler og utløp	SK/MC
Måle vannføringsmålere	SK/MC
Måle vannføringer og utarbeide kapasitetskurver	SK/LEV2
Montere skjermvisning for almennheten	SK/LEV3
Testing av vannføringsmålesystem og fisketellere	SK/NVE/FM

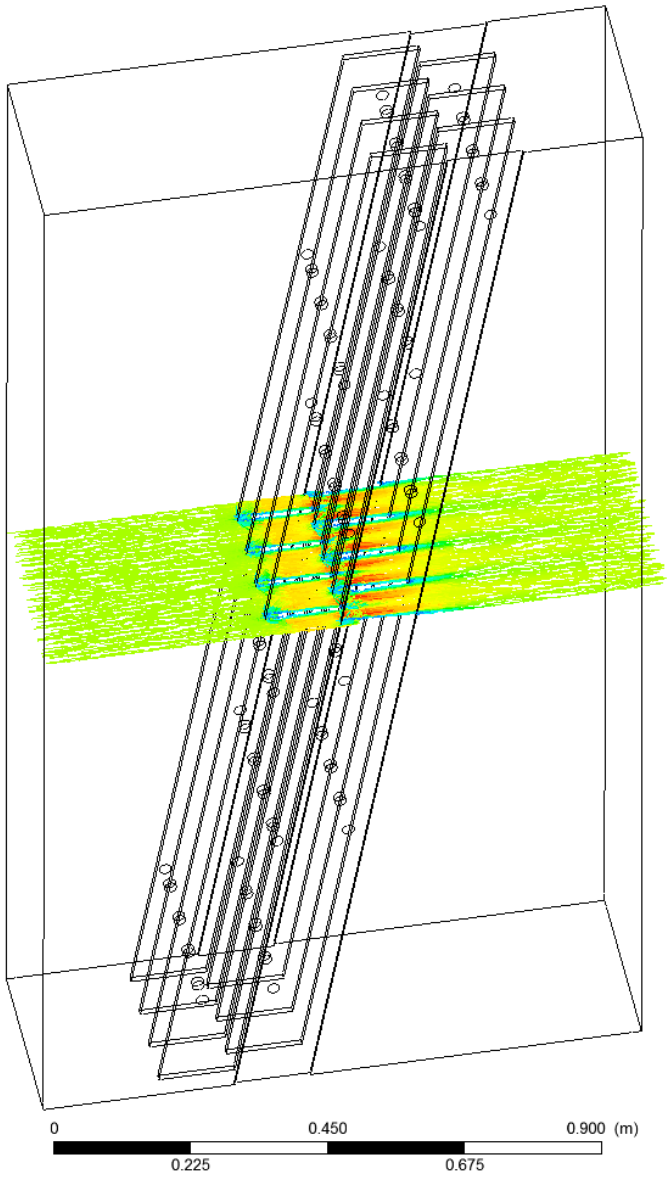


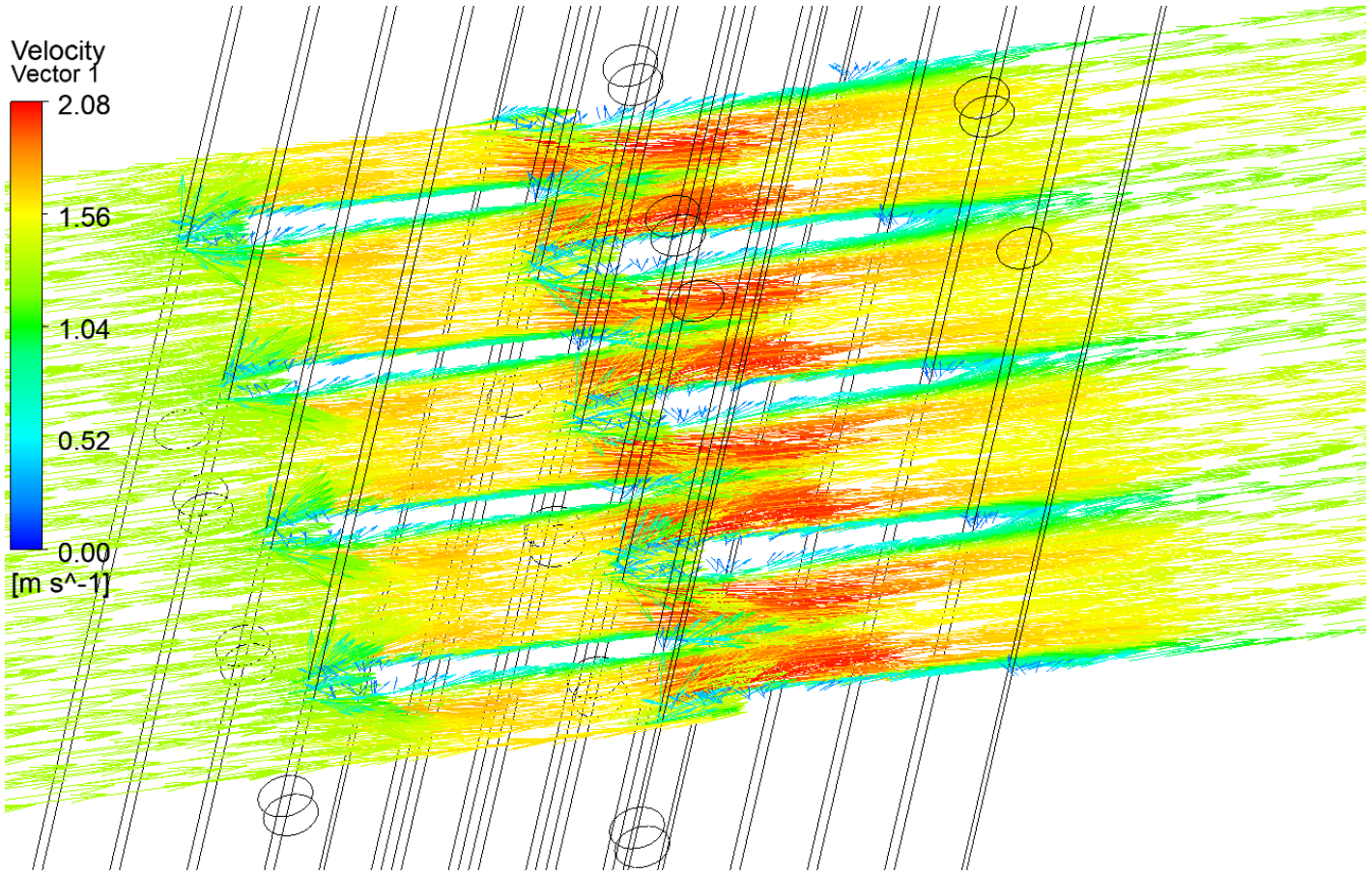

ANSYS
R14.5
0
0.500
1.000 (m)
0.250
0.750
Y
Z
X

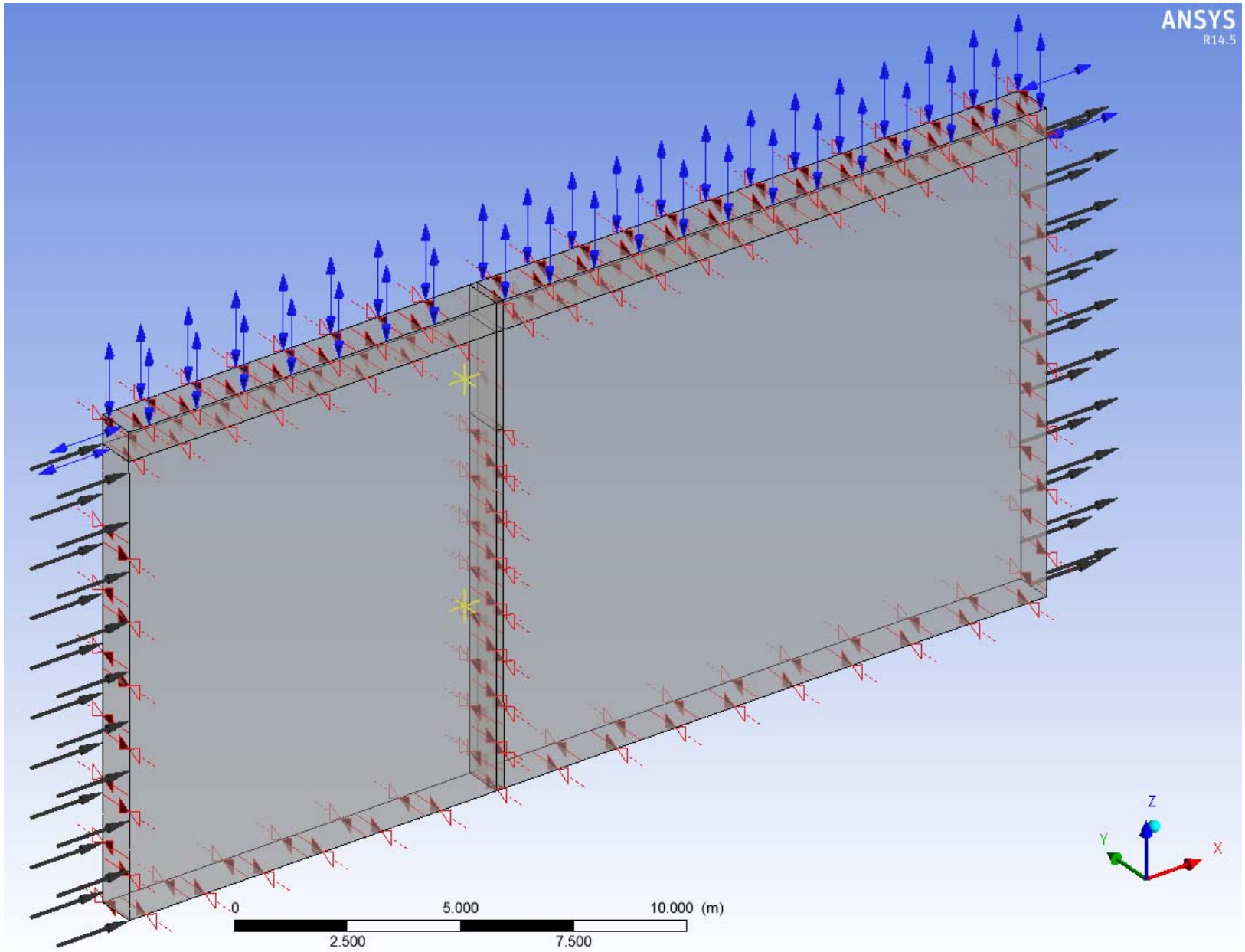

ANSYS
R14.5
0
0.100
0.200 (m)
0.050
0.150
Z
X

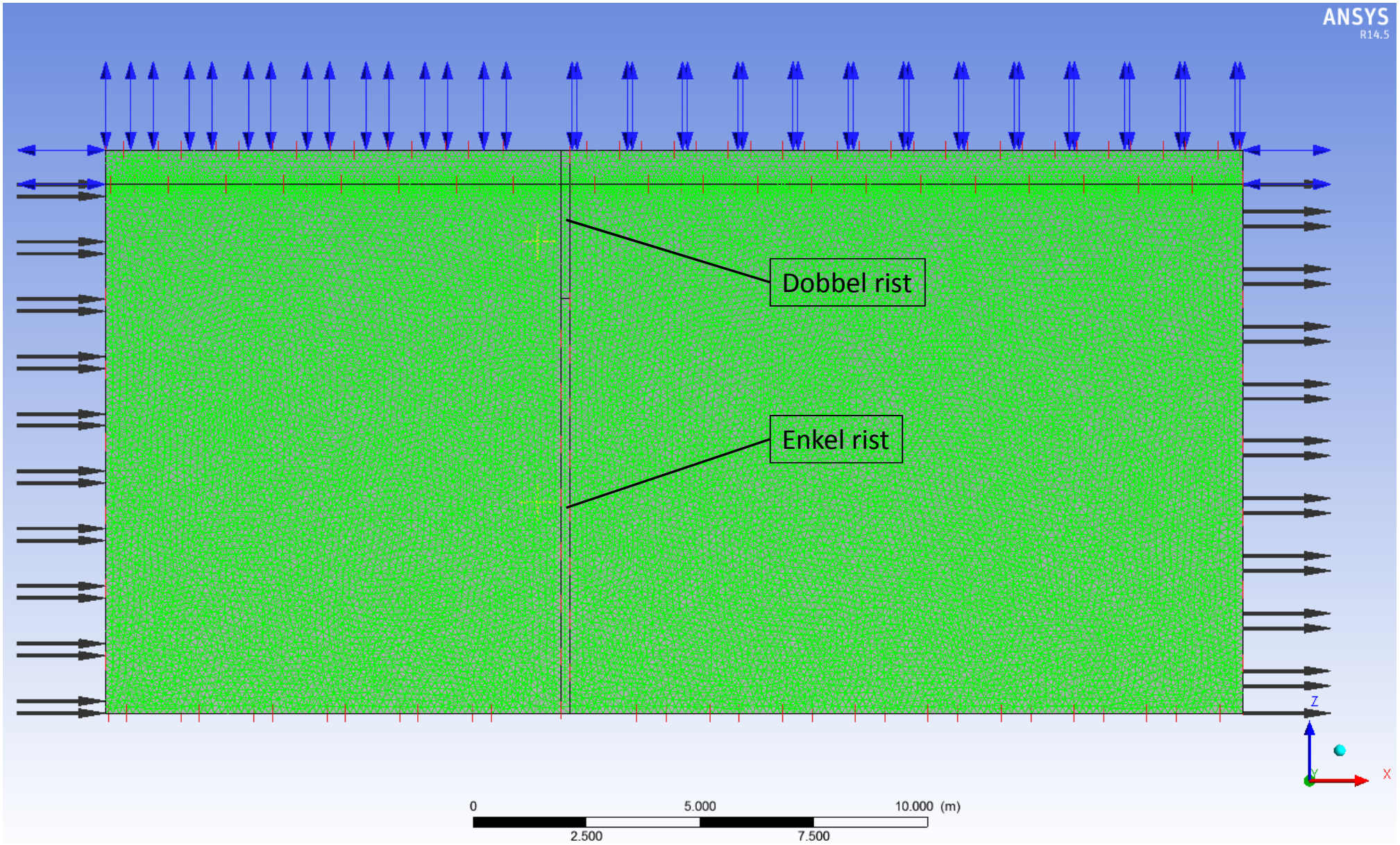


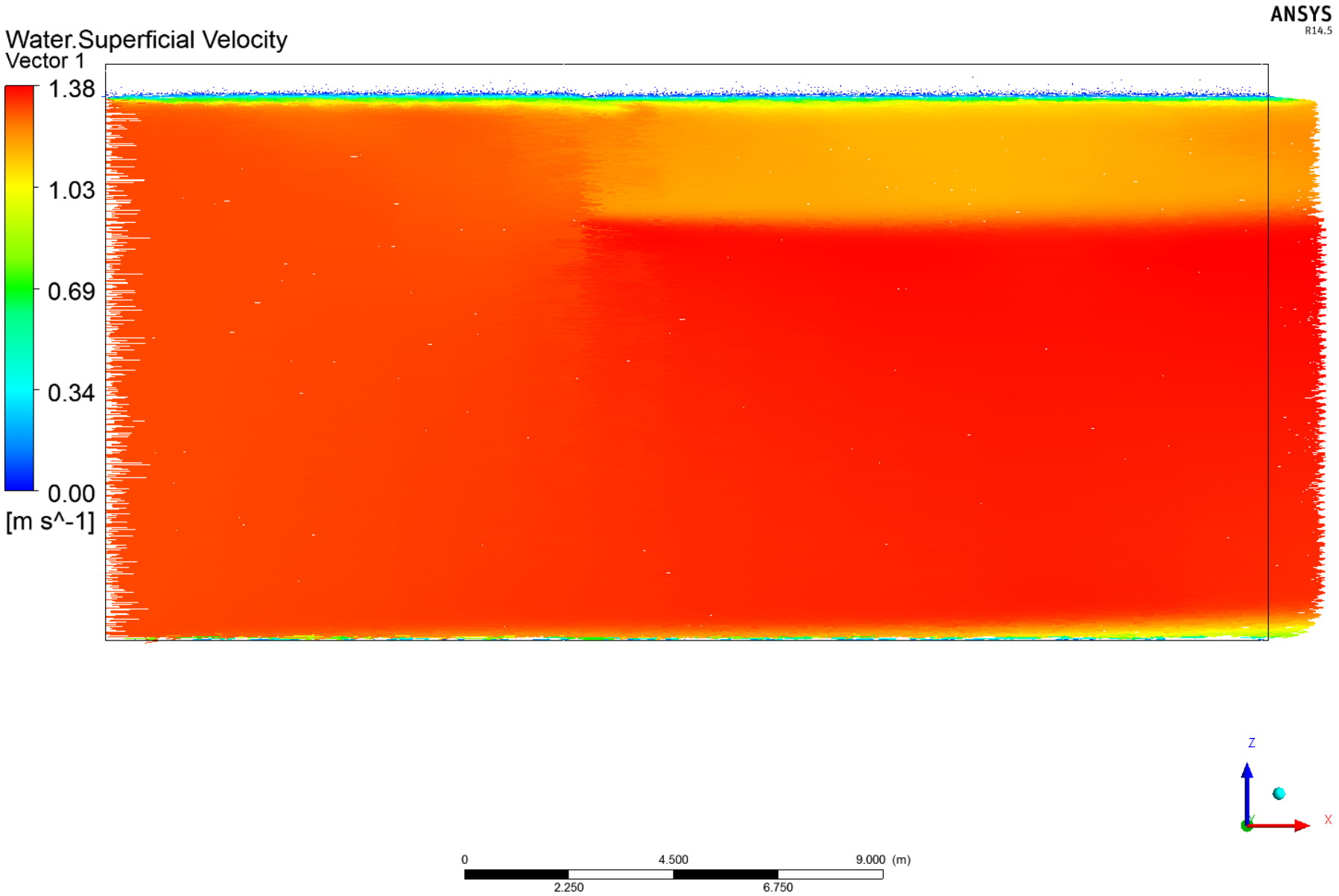
Trykktap over de doble varegrindene er
500 Pa @ 1.30 m/s vannhastighet

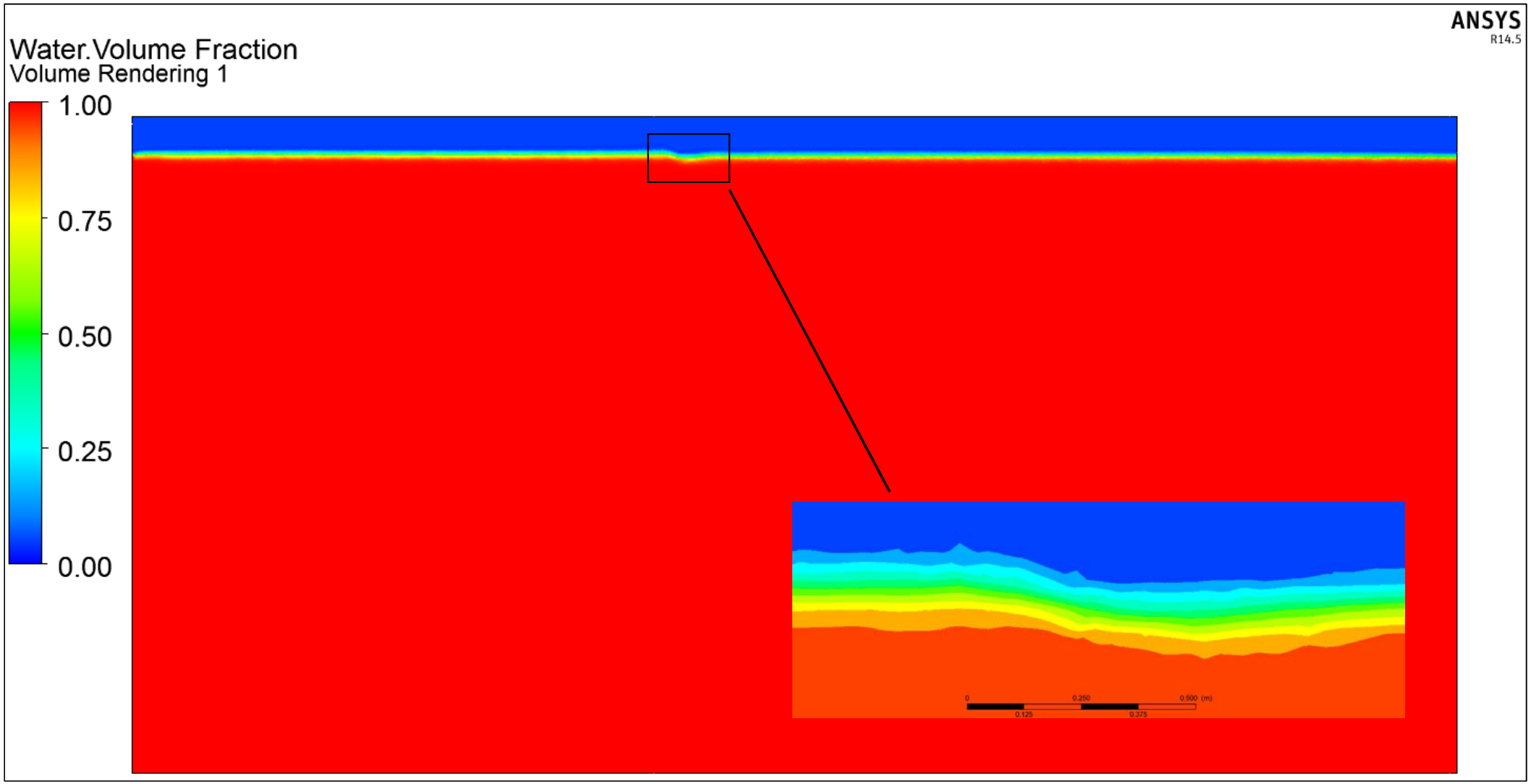

0
0.450
0.900 (m)
0.225
0.675


Velocity
Vector 1
2.08
1.56
1.04
0.52
0.00
[m s^-1]


ANSYS
R14.5
.0
5.000
10.000 (m)
2.500
7.500
Z
Y
X

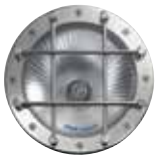

ANSYS
R14.5
Dobbel rist
Enkel rist
Z
Y
X
0
5.000
10.000 (m)
2.500
7.500


ANSYS
R14.5
Water.Superficial Velocity
Vector 1
1.38
1.03
0.69
0.34
0.00
[m s^-1]
Z
X
0
4.500
9.000 (m)
2.250
6.750


ANSYS
R14.5
Water.Volume Fraction
Volume Rendering 1
1.00
0.75
0.50
0.25
0.00
0
0.250
0.500 (m)
0.125
0.375

Surface-mounted Underwater-Light out of 316L stainless steel, 180° adjustable

4.0362 · 4.0302



DESCRIPTION

- Protection system IP68 – for a water depth of up to 3 m
- Made entirely of marine grade 316L stainless steel for POW-LED modules or halogen light sources
- Mounting foot adjustable through 180°
- Cable gland PG16/21, marine grade 316L stainless steel
- Temperature-resistant silicon seal
- Toughened safety glass
- POW-LED-Platine temperatur control (NTC)
- Ballast and ignitor fitted depending on the version
- POW-LED-Version with light source and 3 m cable

ACCESSORIES & POWER SUPPLIES

see page 104 and 179+

REFERENCES

- POW-LED RGBW required an external DMX installation
- SALINE version possible - see table

OPTIONS ON REQUEST

- Radation Angle: POW-LED: 10°, 30°, 45°
- POW-LED monochrome, single colour in green, red, amber, turquoise
- Please order the double cable gland for ring assembly separately (only possible at 12 V-DC version)
- 12 V-DC dimmable with dimming module 5.0690.03.15. Note: Other cable to the spotlight is required. Requires further agreements.
- Water depths of up to 30 m available
- Individual configuration of the LED multichips possible

IP68 · 3 M · V4A EDELSTAHL · CE · III

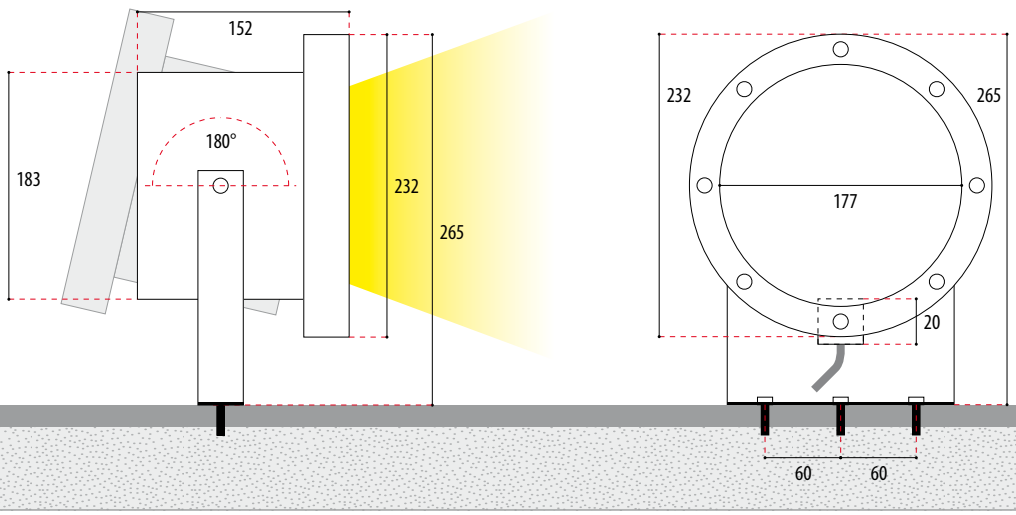
KABEL EXCL · EXCL

POW-LED

KABEL INKL · INKL · NTC CONTROL

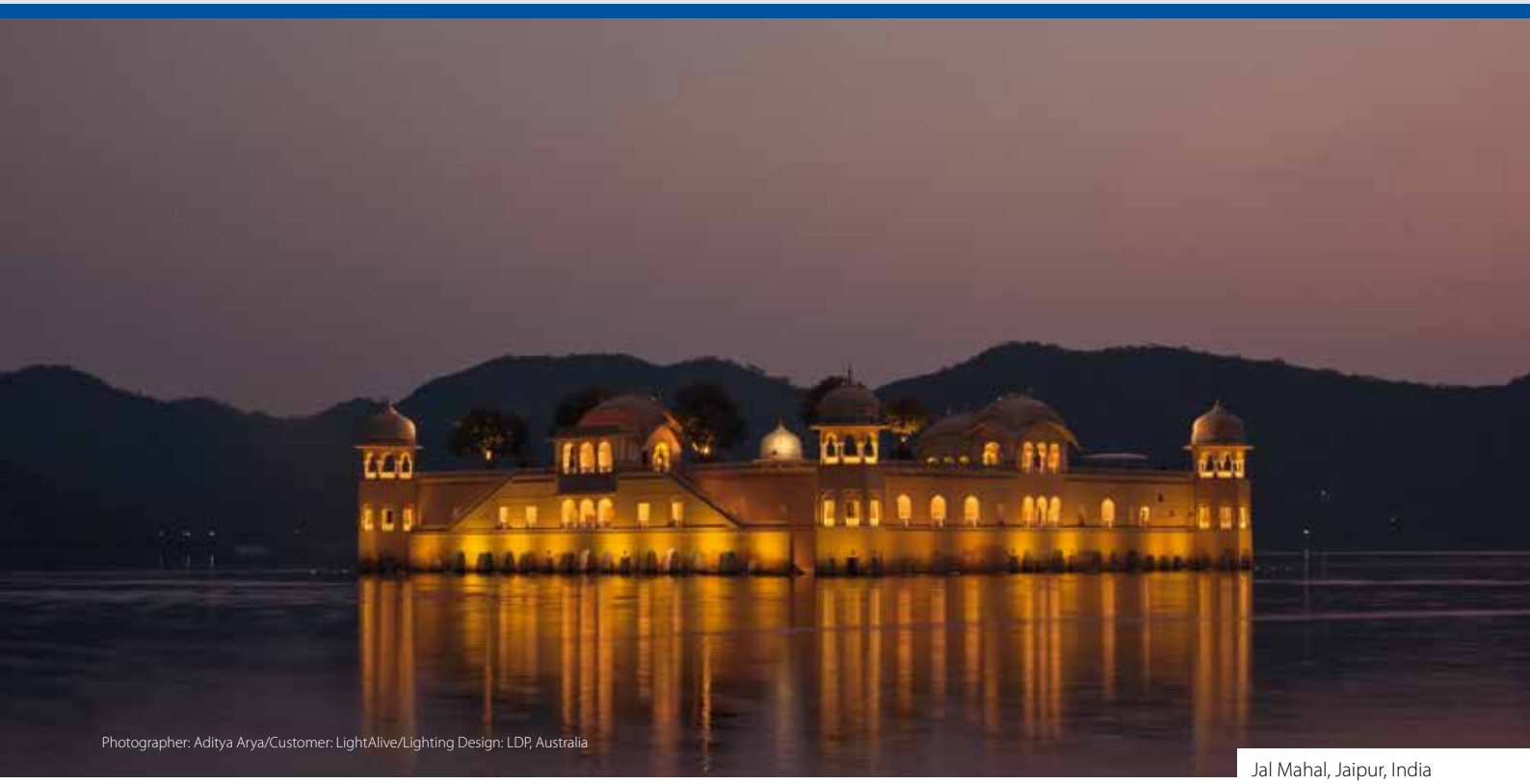
QR-CB51

KABEL EXCL · INKL



Surface-mounted Underwater-Light out of 316L stainless steel, 180° adjustable

4.0362 · 4.0302



Photographer: Aditya Arya/Customer: LightAlive/Lighting Design: LDP, Australia

Jal Mahal, Jaipur, India

Article number	Lamps	Light colour	Wattage (TLF)	Tension	Socket	Radation angle	Cable	No. >205
Versions: Under- and overwater operation (according to prior agreement)								
POW-LED – 350 mA								
4.0362.00.01	36 POW-LED cold white	6.000K	total 43 W (5040 lm)	350 mA	Klemme	30°	UW, 8x0,5 qmm	V73
4.0362.00.02	36 POW-LED warm white	3.000K	total 43 W (3600 lm)	350 mA	Klemme	30°	UW, 8x0,5 qmm	
4.0362.00.03	36 POW-LED neutral white	4.500K	total 43 W (3960 lm)	350 mA	Klemme	30°	UW, 8x0,5 qmm	
4.0362.00.09	36 POW-LED RGB		all on 43 W	350 mA	Klemme	30°	UW, 8x0,5 qmm	
POW-LED – 12 V-DC								
4.0362.00.61	36 POW-LED cold white	6.000K	total 43 W (5760 lm)	12 V-DC	Klemme	30°	UW, 2x2,5 qmm	
4.0362.00.62	36 POW-LED warm white	3.000K	total 43 W (4500 lm)	12 V-DC	Klemme	30°	UW, 2x2,5 qmm	
4.0362.00.63	36 POW-LED neutral white	4.500K	total 43 W (5040 lm)	12 V-DC	Klemme	30°	UW, 2x2,5 qmm	
halogen								
4.0302.00.10	QT12	3.000K	90W	12V-AC	GY6,35	19°	UW, 2x2,5 qmm	B38
4.0302.00.35	HIT-CRI		35W	230V	G12	19°	UW, 3x1,5 qmm	I31
Versions: Only underwater operation								
POW-LED								
4.0362.00.41	12 Multichip POW-LED RGB-CW	6000K	all on 110 W (coldwhite: 2720 lm)	12 V DC		30°	UW, 2x4,0 + 4x0,5 qmm	
4.0362.00.42	12 Multichip POW-LED RGB-WW	3000K	all on 110 W (warmwhite: 2095 lm)	12 V DC		30°	UW, 2x4,0 + 4x0,5 qmm	
4.0362.00.43	12 Multichip POW-LED RGB-NW	4500K	all on 110 W (neutralwhite: 2385 lm)	12 V DC		30°	UW, 2x4,0 + 4x0,5 qmm	
4.0362.00.44	12 Multichip POW-LED RGB-A	amber	all on 110 W	12 V DC		30°	UW, 2x4,0 + 4x0,5 qmm	
halogen								
4.0302.00.00	QT32		150W	230V	E27	24°	UW, 3x1,5 qmm	F33
4.0302.00.25	M36		250W	24V-DC	GY6,35	28°	UW, 2x2,5 qmm	F37
4.0302.00.30	QR-CBC51	3.000K	6 x 50W	12V-AC	GU5,3	36°	UW, 2x2,5 qmm	C95
4.0302.00.38	M38		300W	230V	GY9.5	24°	UW, 3x1,5 qmm	F38
4.0302.00.40	M40		500W	230V	GY9.5	26°	UW, 3x1,5 qmm	F39
4.0302.00.70	HIT-CRI		70W	230V	G12	19°	UW, 3x1,5 qmm	I33
Saline version (saltwater concentration suitable up to 3,5%)								
4.0362.00…S	Refine spotlight as saline-version – Article number with additional „**S**“ at the end (e.g. 4.0362.00.01**S**)							

Surface-mounted Underwater-Light out of 316L stainless steel

power supplies & Accessories – 4.0095 · 4.0097 · 4.0192 · 4.0195 · 4.0302 · 4.0305 · 4.0362 · 4.0365

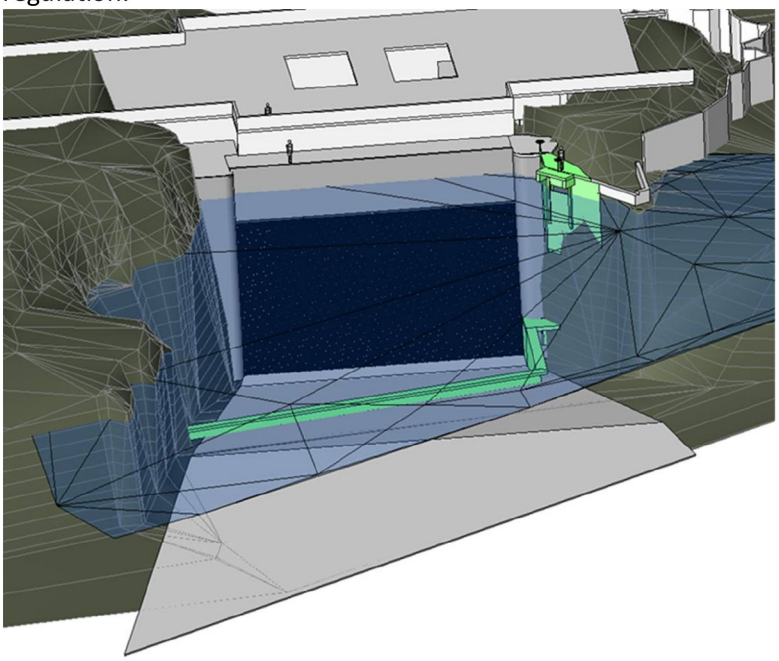
Spotlight ↓	Power supplies											Accessories																
	5.0635.00.36 Power supply – for max. 3 x 12 POW-LED 350 mA, IP65 – see page 180	**5.0600.65.60 Power supply** – for max. 36 POW-LED 12 V-DC, IP65 – see page 180	**5.0600.65.15 Power supply** – for max. 108 POW-LED 12 V-DC, IP65 – see page 180	**5.0635.09.50 RGB-Controler** – for max. 36 POW-LED RGB, 350 mA, IP65 – see page 182	**5.0670.09.52 RGBW-Controler** – IP20, for H-rail mounting, 12 V-DC, 1-130 W, for max. 1 spotlight, DMX in/out, Master/Slave, Stand-alone programms – see page 182	**5.0670.09.18 RGB-Controler** – for max. 18 POW-LED RGB, 700 mA, IP65 – see page 182	**5.0100.00.00 Transformer** – 2 x 50 W, 100 VA. 12 V-AC – see page 185	**5.0101.00.00 Transformer** – 2 x 75 W, 150 VA, 12 V-AC – see page 185	**5.0103.00.00 Transformer** – 2 x 175 W, 350 VA, 12 V-AC – see page 185	**5.0312.00.01 Transformer** – 1 x 250 W, 250 VA, 24 V-DC – see page 185	**4.0003.01.00 anti-glare louver** – black, for symm. and asymm. Reflector	**4.0003.02.00 anti-glare louver** – black, for adjustable Reflector	**4.0003.01.01 anti-glare louver** – black	**4.0003.02.01 anti-glare louver** – black	**4.0004.40.13 double cable gland** – made of V4A-stainless steel	**4.0004.40.16 double cable gland** – made of V4A-stainless steel	**4.0009.00.20 angular ring** – with 2 protection bars	**4.0009.00.40 angular ring** – with 4 protection bars	**4.0066.01.00 glass disc, frosted** – for softer light distribution (light loss approx. -15%)	**4.0230.01.00 glass disc, frosted** – for softer light distribution (light loss approx. -15%)	**4.0230.04.00 colour disk** – yellow	**4.0230.05.00 colour disk** – red	**4.0230.06.00 colour disk** – blue	**4.0230.07.00 colour disk** – green	**4.0232.04.00 colour filter, dichroitic** – yellow	**4.0232.05.00 colour filter, dichroitic** – red	**4.0232.06.00 colour filter, dichroitic** – blue	**4.0232.07.00 colour filter, dichroitic** – green	**4.0305.50.00 spike** – 395 mm
4.0095-97.00.00											●					●	●	●		●	●	●	●				●
4.0095-97.00.15											●					●	●	●		●	●	●	●				●
4.0095-97.00.16												●				●	●	●		●	●	●	●				●
4.0095-97.00.17												●				●	●	●		●	●	●	●				●
4.0095-97.00.70											●					●	●	●		●	●	●	●				●
4.0095-97.00.71												●				●	●	●		●	●	●	●				●
4.0095-97.00.80											●					●	●	●		●	●	●	●				●
4.0095-97.00.81											●					●	●	●		●	●	●	●				●
4.0192.18-90.01	●													●					●								●
4.0192.18-90.02	●													●					●								●
4.0192.18-90.03	●													●					●								●
4.0192.18-90.09				●										●					●								●
4.0192.18-90.10							●							●					●								●
4.0192.18-90.15								●						●					●								●
4.0192.18-90.39						●								●					●								●
4.0192.18-90.61		1-3	1-9											●													
4.0192.18-90.62		1-3	1-9											●													
4.0192.18-90.63		1-3	1-9											●													
4.0195.18-90.01														●					●								●
4.0195.18-90.02														●					●								●
4.0195.18-90.03														●					●								●
4.0195.18-90.10															●				●					●	●	●	●	●
4.0195.18-90.18															●				●					●	●	●	●	●
4.0195.18-90.20														●	●				●					●	●	●	●	●
4.0195.18-90.21														●	●				●					●	●	●	●	●
4.0195.18-90.22														●	●				●					●	●	●	●	●
4.0195.18-90.23														●	●				●					●	●	●	●	●
4.0195.18-90.35														●	●				●					●	●	●	●	●
4.0195.18-90.36														●	●				●					●	●	●	●	●
4.0195.18-90.37														●	●				●					●	●	●	●	●
4.0195.18-90.38														●	●				●					●	●	●	●	●
4.0305-302.00.00											●					●	●	●		●	●	●	●				●
4.0305-302.00.10							●				●					●	●	●		●	●	●	●				●
4.0305-302.00.25										●	●					●	●	●		●	●	●	●				●
4.0305-302.00.30									●		●					●	●	●		●	●	●	●				●
4.0305-302.00.35											●					●	●	●		●	●	●	●				●
4.0305-302.00.38											●					●	●	●		●	●	●	●				●
4.0305-302.00.40											●					●	●	●		●	●	●	●				●
4.0305-302.00.50											●					●	●	●		●	●	●	●				●
4.0305-302.00.70											●					●	●	●		●	●	●	●				●
4.0362.00.01	●																										
4.0362.00.02	●																										
4.0362.00.03	●																										
4.0362.00.09				●																							
4.0362.00.41-44					●																						
4.0362.00.61		1	1-3																								
4.0362.00.62		1	1-3																								
4.0362.00.63		1	1-3																								
4.0365.00.01	●																										●
4.0365.00.02	●																										●
4.0365.00.03	●																										●
4.0365.00.09				●																							●
4.0365.00.41-44					●																						●
4.0365.00.61		1	1-3																								●
4.0365.00.62		1	1-3																								●
4.0365.00.63		1	1-3																								●

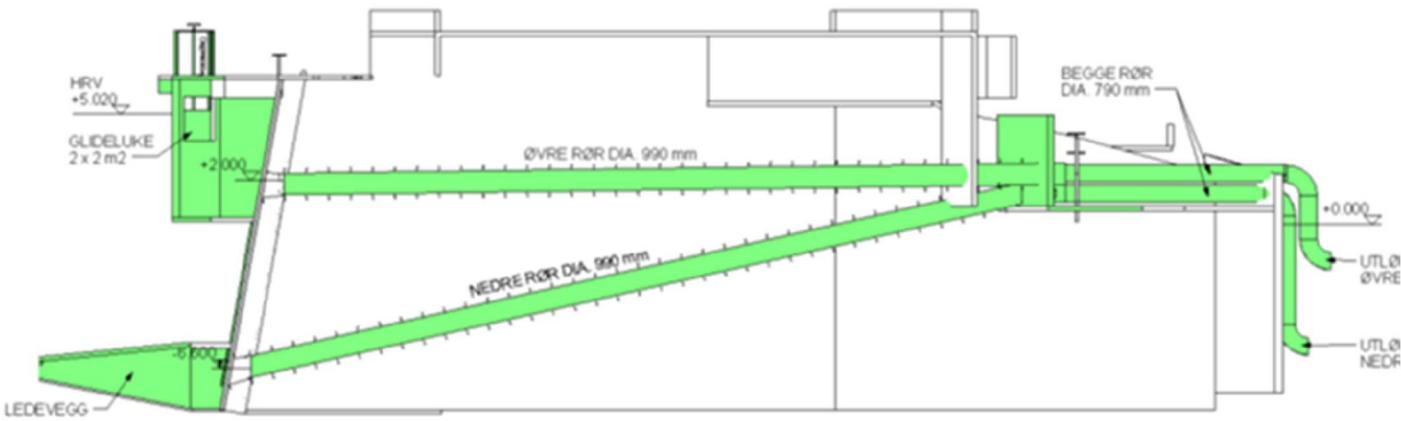
Kópavogur, Iceland 4.November 2016

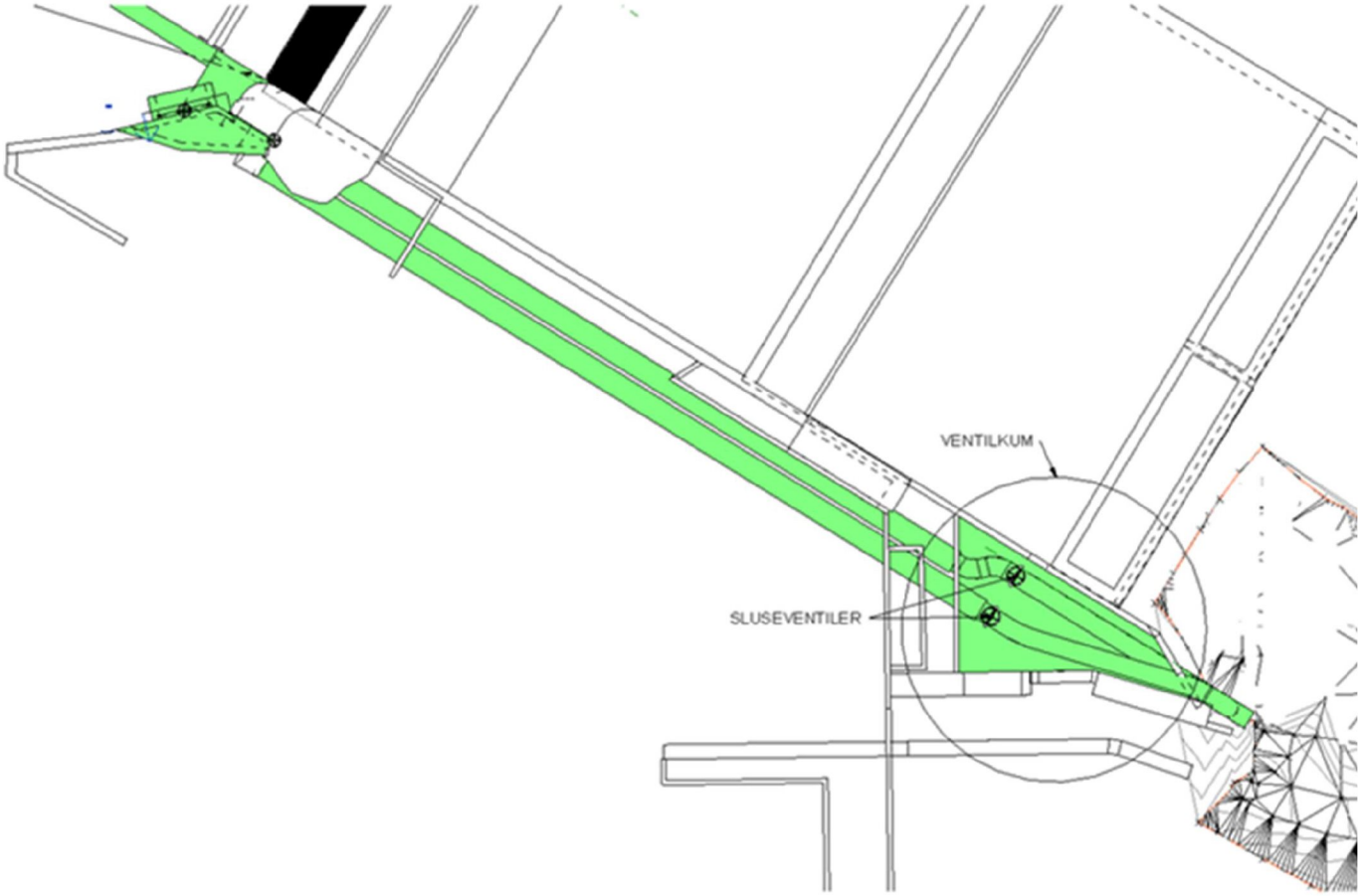
Klosterfoss – Fish monitoring proposal

Project description:
The smolt tube is dimensioned for large capacity, i.e. a maximum of 4m3 / s. To release 4 m3 / s the inlet must be total aperture width at least 2.7 m when the water depth is 1.0 m.

The following illustrations are from an updated 3D model. There are two tubes for fish migration. The top tube is for smolt and winter fish, and the lower tube is for eels. Both pipes shall have an internal diameter of 990 mm in full length. Both tubes are basically from concession dropping 2.5 m3 / s each, but such large pipes may be able to drop up to 4 m3 / s each. That means there will have a minimum water velocity = 3.25 m / s and maximum water velocity = 5.2 m / s. Notice that there is a breather on the smolt pipe valve manhole. The water flow in both pipes shall be regulated in the inlets. Water flow in smolt pipe shall be governed by syphon and stop logs. Water flow in eels pipe shall be governed by a sliding hatch. The valves in valve manhole will only be fully open or fully closed, ie not used for regulation.




HRV
+5.020
GLIDELUKE
2 x 2 m2
+2.000
ØVRE RØR DIA. 990 mm
BEGGE RØR
DIA. 790 mm
+0.000
NEDRE RØR DIA. 990 mm
LEDEVEGG


VENTILKUM
SLUSEVENTILER

Particle content

Klosterfoss gets nearly all of its water from Norsjø (catchment barely 10,000 km2). Approximately ¾ of Norsjø lies so high above sea level that there are usually little erosion in soils. There are no glaciers in the catchment area. The intake to Skotfoss power plant is rather shallow; ie surface water in Norsjø which flows from Norsjø down to Klosterfoss.

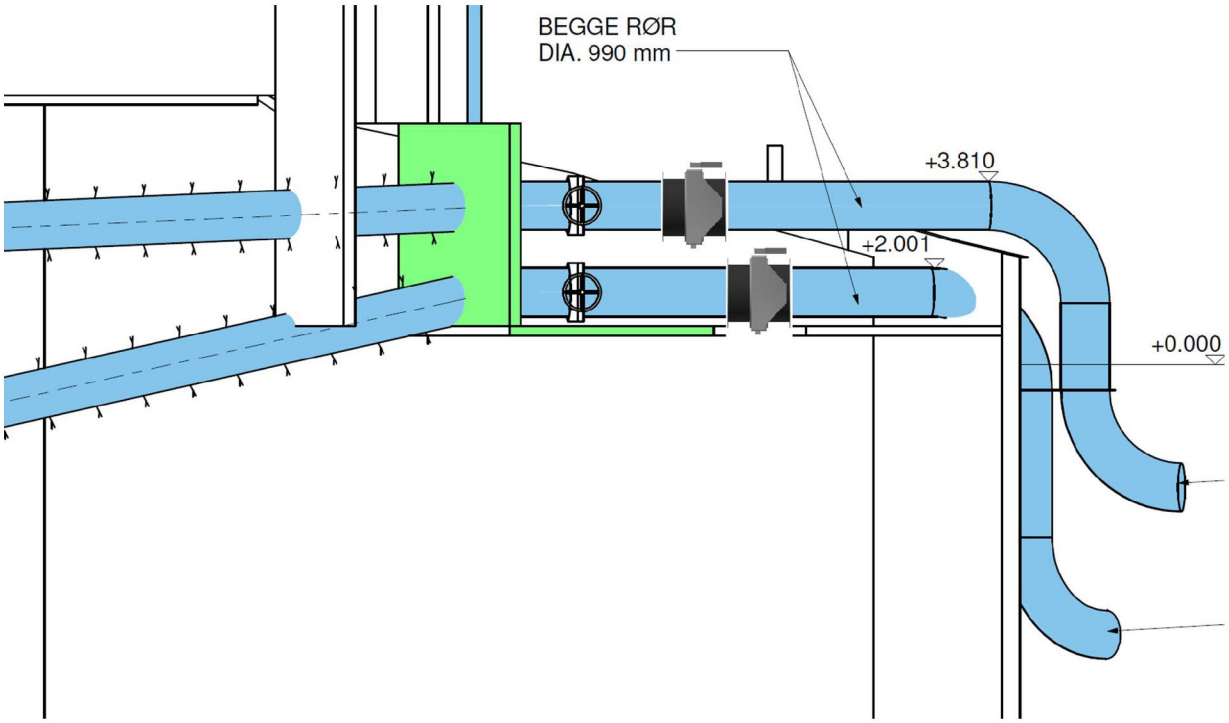
Klosterfoss also get some water from Falkum River (catchment area of about 300 km2). The area around Norsjø and the lower part of Falkum river is farmland, where in the spring there can be significant erosion in soils. In periods with some erosion (spring and autumn with heavy rains (for example spring 2013 and autumn 2000)) the clay content increases in the upper water layer in Norsjø. The turbidity increases to more than 10 FNU. There are no systematic measurements of the turbidity in the upper water layer, but the turbidity can for sure be higher than 10 FNU. Particles are mainly within the clay fraction, but some silt particles may as well be carried by the water.
The erosion in the tributary Falkum River can be considerable. In short high flow periods the water from Falkum River can be nearly black.

However, Norsjø is so big that sand and coarser particles will be deposited where the incoming rivers flow into Norsjø. The clay fraction (particle size less than 2/1000 mm or 0,002 mm) is suspended in the water flowing through Norsjø. Normally the content of clay is limited, and most of the year the upper layer of water has a turbidity that is smaller than 3 FNU. It means that the coloring of the water flowing from Norsjø to Klosterfoss is minimum.

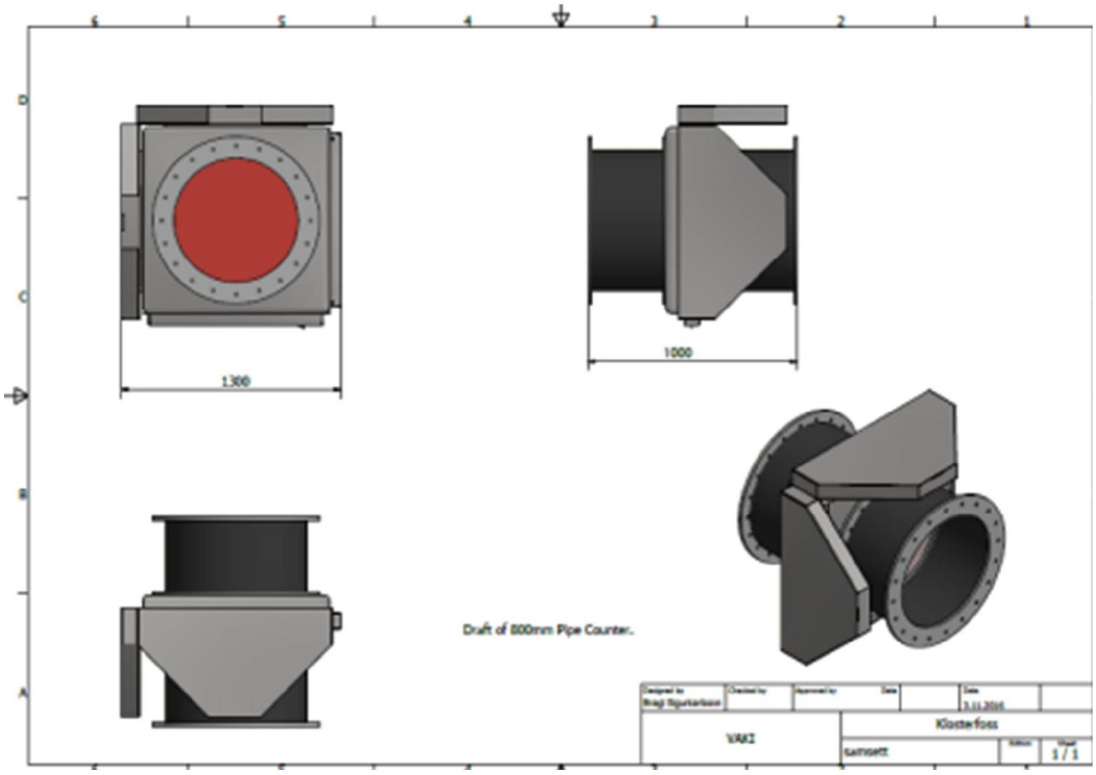
So most of the particles in the water at Klosterfoss is within the clay fraction and most of the year the particle content is low.

Monitoring proposals:

Pipe Counters:
Our proposal for the down migrating smolt and eels is to install optical counters inside the pipes at the valve sump. These pipe counters are based on a digital scanning cameras and computer vision. The fish passing through the counter are recorded and our custom designed software is used to analyze the images and count the individuals. At each pipe, two digital line cameras will be directed to a bright white light to scan all passing fish. The water velocity, debris and turbulence inside the pipe will make it challenging in the smolt bypass but we believe this is the best option to count both smolts and eels at this location.



Each pipe counter is placed towards the end of the tunnel before the water exits the pipe. Each counter is connected to a PC with all the needed software. Each counter needs one meter length of pipe. The data will be shown on the PC and can be uploaded automatically to Riverwatcher Daily Klosterfoss page.



These counters are a totally new design and will be piloted at Klosterfoss. Each has two cameras on an angle that scan all moving objects.

Riverwatcher Fish Counter:
We would also like to propose for consideration to use this opportunity to renew the monitoring of upstream migration through the fish way.

The scanner triggers the camera to capture a short video clip of each fish. The computer then automatically links the images to the other information contained in the database for that individual fish such as size, passing hour, speed, silhouette image, temperature etc.

The camera is installed in a special tunnel that contains both the camera and lights providing constant light and same distance from the camera for the fish. That way it is possible to get good images of the fish regardless of time of day.

A PIT-Tag Riverwatcher would be perfect for monitoring the upstream migration at Klosterfoss. This Riverwatcher not only counts and measures the entire migration and provides video clips of each fish but also identifies tagged individuals as well.

ElverWatcher eel counter:
Furthermore we suggest an ElverWatcher to count the small eels entering the river.

We suggest an eel pass around the dam to be fitted with the latest ElverWatcher to count the up migrating small eels. When the elvers reach the top of the ladder they are gently flushed with water through the counter where they are counted and recorded. Our custom software is used to analyze the images and count the individuals. The software shows a graphical representation of the position and quantity elvers passing through the counter across the scanning area. The Elverwatcher can count juvenile eels from 0.1 g and it can show the real time camera image of the scanning area to view how the small eels pass through the counter and identify any obstructions or objects that might remain in the camera´s field of view.

Quotation:

First pipe counter:	857.142-NOK
Second pipe counter:	571.428-NOK
Riverwatcher Fish counter:	395.495-NOK
Elverwatcher eel counter	242.849-NOK
PIT-Tag package add on	142.857-NOK

Included:
All software, all equipment, Riverwatcher Daily access, all cables, installation, online support.

Not included:
Internet connection, grids and in-scales, eel ladder, water for flushing eels, PIT-Tags for fish,

Payment terms:
50% prepayment is required for all items. The remaining 50% is paid when Vaki delivers the equipment. All counters have two years warranty.

Other terms:
The site design must take into consideration that some access to the equipment is needed for cleaning and maintenance. We need to be able shut down the water above the counters for this reason.

All possible measures must be taken to clear the water of debris. Debris going down the pipes can create false counts and jeopardize the efficiency and accuracy of the counter. Furthermore, turbulence and turbidity can create false counts and affect the accuracy of the counter.

Vaki takes no responsibility for false counts or poor performance caused by debris, turbulence and turbidity or any other environmental factors.

Vaki requires full access to all the data for R&D.

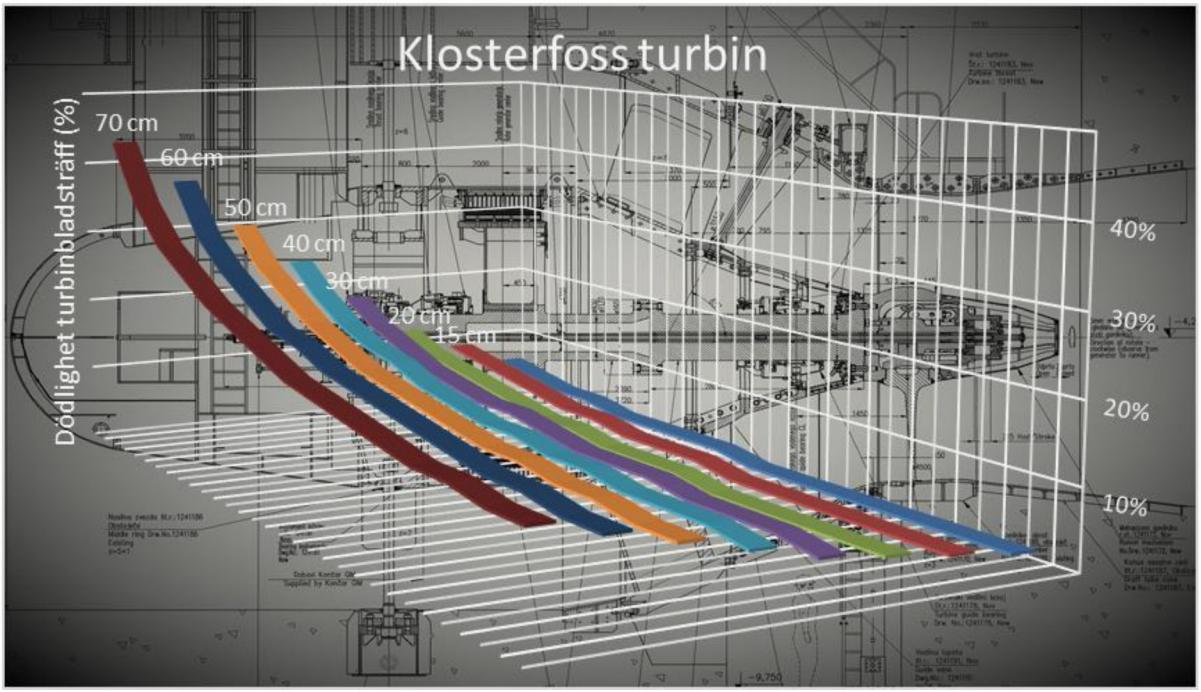
On behalf of Vaki Aquaculture Systems Ltd. ,

Magnus Thor Asgeirsson

Project Manager

Klosterfoss

-Beräkning av dödlighet på fisk vid nedströms passage genom turbin



Projekt: Rapport 2017-01-13. Klosterfoss –beräkning… dödlighet… turbin..
Ort och datum: Hörnefors 2017-01-13
Utförare: EKOM AB
Uppdragsansvarig: Per Lundström

Uppdragsansvarig

EKOM AB
Hörnefors Företagscentrum
905 31 Hörnefors
www.ekom.se

Innehållsförteckning

Bilagor:
1. Tabell resultat beräkning av dödlighet vid passage genom befintlig turbin.
2. Tabell resultat beräkning av dödlighet vid passage genom ny turbin.
3. Figurer jämförelse av beräknad dödlighet vid passage genom befintlig- och ny turbin.
4. Turbindata använda vid beräkning av fiskdödlighet vid turbinpassage

1 Bakgrund

Multiconsult AS ställde via mail 2016-12-08 en förfrågan till EKOM AB om genomförande av beräkning av fiskdödlighet vid passage genom såväl befintliga- som planerat nya turbiner i Klosterfoss kraftverk.

Akershus Energi Vannkraft AS gav 2016-12-21 EKOM i uppdrag att genomföra beräkningarna.

2 Material och metoder

Turbindata och övrig information om Klosterfoss har givits via mail 2016-12-08 av Jan Høiseth, Multiconsult AS och 2017-01-09 av Bjørnar Petersen, Akershus Energi Vannkraft AS.

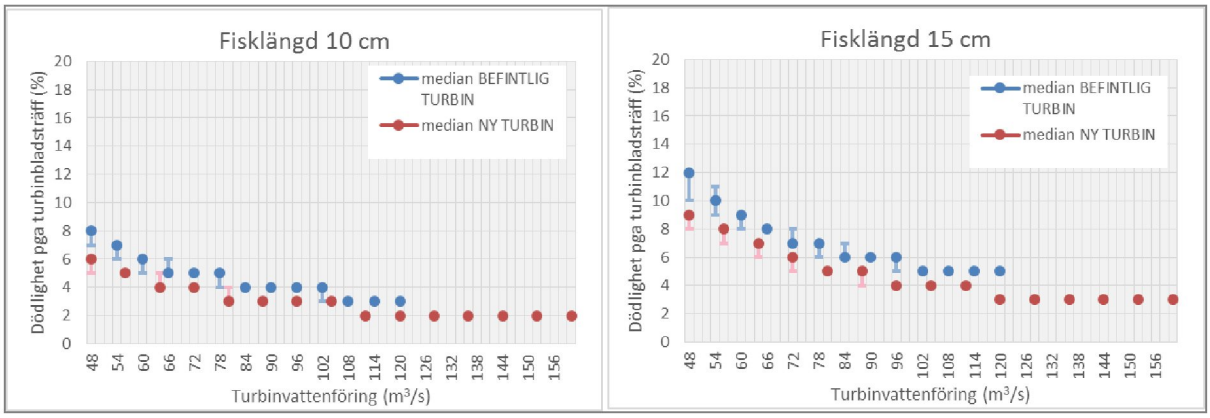
Beräkningar av fiskdödlighet p.g.a. turbinbladsträff vid passage genom turbin har gjorts av Per Lundström EKOM AB. Beräkningar har utförts enligt modellverktyg framtaget av Kjell Leonardsson (Leonardsson 2014). Beräkningar omfattar ej eventuell dödlighet vid passage genom turbinens ledapparat. Dock bedöms dödlighet genom ledapparat generellt sett som lägre jämfört med dödlighet p.g.a. turbinbladsträff (Leonardsson muntligt 2017).

3 Resultat

Klosterfoss kraftverk är utrustat med 2 rörturbiner med slukförmåga om vardera 120 m^3/S. Befintliga turbiner avses att bytas ut mot nya rörturbiner. De nya rörturbinerna avses att få en slukförmåga om vardera 160 m^3/s. Vidare kommer nya turbinerna att ha 3- istället för 4 turbinblad och drivas med högre aningen högre varvtal (bilaga 4). Lägsta turbinvattenföring i såväl befintliga som planerat nya turbiner är 50 m^3/s.

Såväl befintliga som planerat nya turbiner kan beskrivas som stora, grovbladiga med låga varvtal. Genomförda beräkningar visar på generellt låg dödlighet framförallt vad avser liten fisk vid passage med höga drivvattenföringar. Framför turbinernas intag finns intagsgaller med spaltöppning 68 mm. Intagsgaller generellt har visat sig mekaniskt hindra fisk med en längd uppgående till mer än 10 ggr spaltöppningen (Larinier M. Travade F. 2002.). Intagsgallret bedöms därför hindra fisk längre än ca 70 cm från att passera genom turbin.

Planerat nya turbiner har genomgående lägre dödlighet jämfört med befintliga (figur 1 och bilaga 3). Medianvärdena för dödlighet vid drivvattenföring 48-, 72-, 96- och 120 m^3/s beräknas vara ca 20 – 30 % lägre i planerat nya turbiner jämfört med befintliga. Den lägre dödligheten avser samtliga fisklängder i intervallet 10 – 70 cm (tabell 1).



Figur 1. Jämförelse av beräknad dödlighet p.g.a. turbinbladsträff vid passage genom befintlig- och ny turbin i Klosterfoss, ex fisklängd 10- och 15 cm. Punkter avser medianvärden och staplar avser värden för 25- och 75%-percentilen. Figurer för samtliga fiskängder kan ses i bilaga 3.

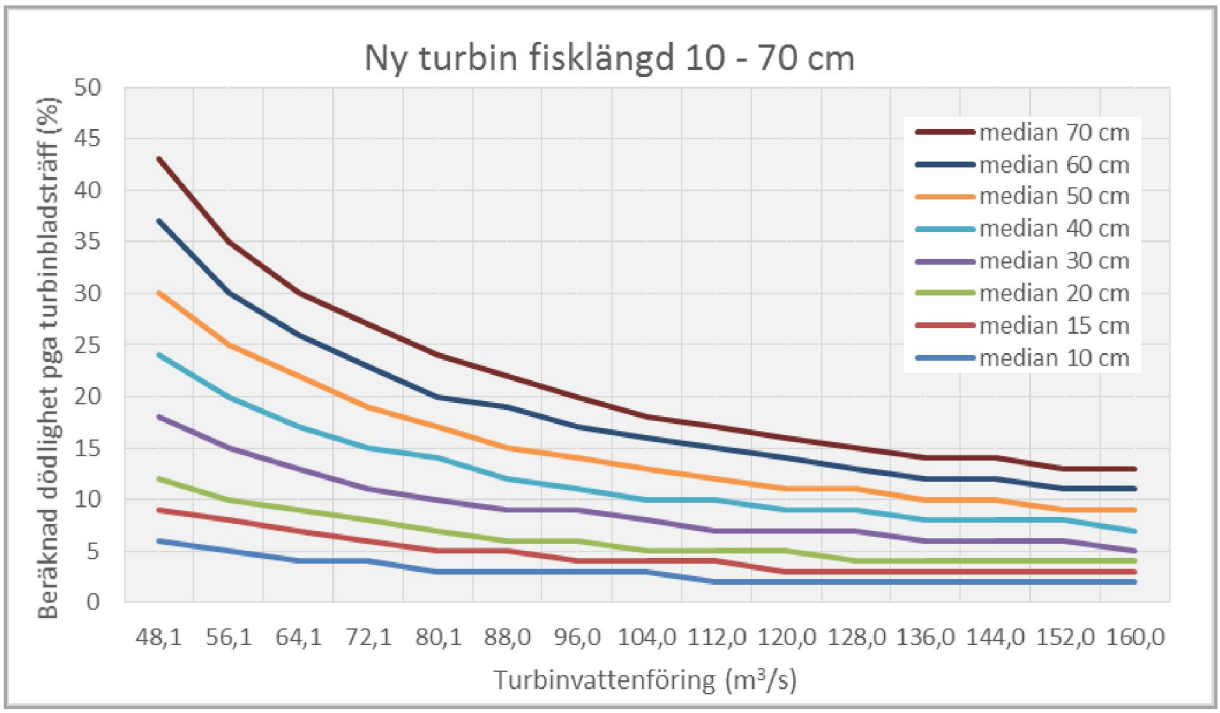
Tabell 1. Beräknade medianvärden för dödlighet p.g.a. turbinbladsträff vid turbinpassage med turbinvattenföring 48-, 72-, 96- och 120 m^3/s. Värden avser medianvärden samt procentuell minskning med ny- jämfört med befintlig turbin.

Fisklängd (cm)	10			15			20			30		
Turbinvatten-föring (m^3/s)	MBT	MNT	Minskn	MBT	MNT	Minskn	MBT	MNT	Minskn	MBT	MNT	Minskn
48	8	6	25,0%	12	9	25,0%	16	12	25,0%	24	18	25,0%
72	5	4	20,0%	7	6	14,3%	10	8	20,0%	15	11	26,7%
96	4	3	25,0%	6	4	33,3%	8	6	25,0%	11	9	18,2%
120	3	2	33,3%	5	3	40,0%	6	5	16,7%	10	7	30,0%
Medelv. minskad dödlighet:			***25,8%***			***28,2%***			***21,7%***			***25,0%***
Fisklängd (cm)	**40**			**50**			**60**			**70**		
Turbinvatten-föring (m^3/s)	**MBT**	**MNT**	**Minskn**	**MBT**	**MNT**	**Minskn**	**MBT**	**MNT**	**Minskn**	**MBT**	**MNT**	**Minskn**
48	31	24	22,6%	39	30	23,1%	47	37	21,3%	55	43	21,8%
72	20	15	25,0%	25	19	24,0%	30	23	23,3%	35	27	22,9%
96	15	11	26,7%	19	14	26,3%	23	17	26,1%	26	20	23,1%
120	13	9	30,8%	16	11	31,3%	19	14	26,3%	22	16	27,3%
Medelv. minskad dödlighet:			***26,3%***			***26,2%***			***24,3%***			***23,8%***
MBT = mediandödlighet befintlig turbin, MNT = mediandödlighet ny turbin												

Den beräknade dödligheten i de nya turbinerna är lägre vid hög drivvattenföring jämfört med låg drivvattenföring (figur 2). Medianvärdena för dödlighet vid drivvattenföring 160 m^3/s beräknas vara ca 30 - 50 % lägre jämfört med dödligheten vid drivvattenföring 80 m^3/s. Den lägre dödligheten avser samtliga fisklängder i intervallet 10 – 70 cm (tabell 2). Vid totala vattenföringar i intervallet 50 – 160 m^3/s erhålles därför preliminärt en högre överlevnad vid nedströms passage genom turbin om allt vatten tillåts passera genom en turbin. Vid högre vattenföringar än 160 m^3/s inverkar fördelning av drivvattenföring/turbin preliminärt mindre på överlevnad.

Tabell 2. Beräknade medianvärden för dödlighet p.g.a. turbinbladsträff vid turbinpassage i ny turbin. Värden avser medianvärden samt procentuell minskning med turbinvattenföring 160- jämfört med 80 m^3/s.

Fisklängd (cm)	Turbinvattenföring (m^3/s)		Andel lägre dödlighet (%)
	80	160	
10	3	2	33,3%
15	5	3	40,0%
20	7	4	42,9%
30	10	5	50,0%
40	14	7	50,0%
50	17	9	47,1%
60	20	11	45,0%
70	24	13	45,8%
Medelv. minskad dödlighet:			***44,3%***



Figur 2. Beräknad dödlighet för olika fisklängder vid passage genom ny turbin vid olika drivvattenföringar. Värden avser medianvärden.

4 Referenser

Larinier M. Travade F. 2002. Bull. Fr. Peche Piscic. (2002). Chapter 13. Downstream migration: Problems and facilities.

Leonardsson 2014. Leonardsson Kjell. Sveriges lantbruksuniversitet. 2014-05-06. Interaktiv analys av förluster av nedströmsvandrande fisk i samband med kraftverkspassager - version för lax. Ver 2.0 cdf.

Leonardsson muntligt 2016. Leonardsson Kjell. Sveriges lantbruksuniversitet. Telefonsamtal 2017-01-13.

5 Bilagor

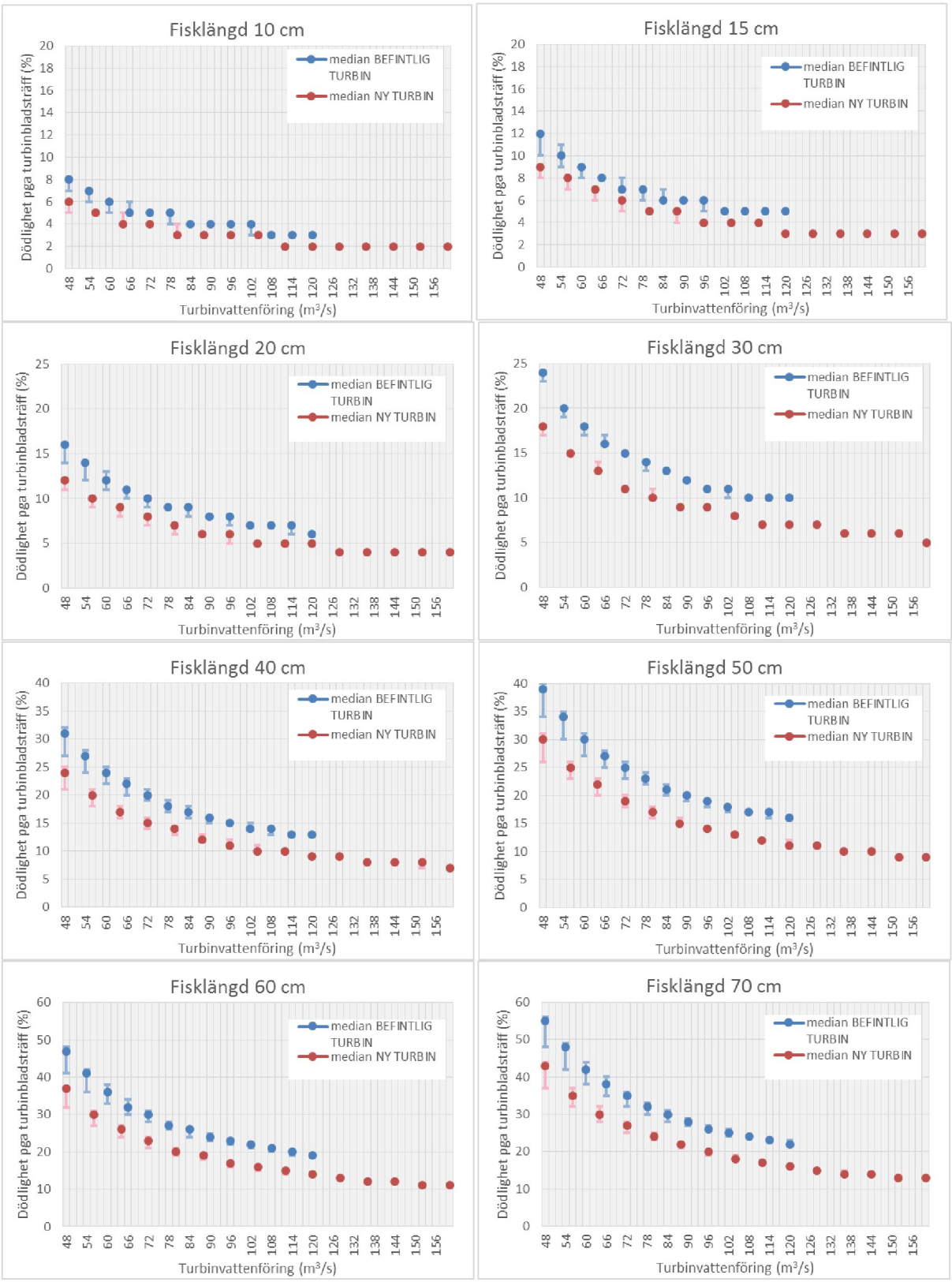
Bilaga 1. Tabell resultat beräkning av dödlighet vid passage genom befintlig turbin.

Beräknad dödlighet (%) pga turbinbladsträff BEFINTLIG turbin																									
Fisklängd (cm):		10			15			20			30			40			50			60			70		
Turbinvatten-föring (m^3/s)		25% - p	median	75% - p	25% - p	median	75% - p	25% - p	median	75% - p	25% - p	median	75% - p	25% - p	median	75% - p	25% - p	median	75% - p	25% - p	median	75% - p	25% - p	median	75% - p
48,1		7	8	8	10	12	12	14	16	16	20	24	24	27	31	32	34	39	40	41	47	48	48	55	56
54,1		6	7	7	9	10	11	12	14	14	18	20	21	24	27	28	30	34	35	36	41	42	42	48	49
60,1		5	6	6	8	9	9	11	12	13	16	18	19	22	24	25	27	30	31	33	36	38	38	42	44
66,0		5	5	6	8	8	8	10	11	11	15	16	17	20	22	23	25	27	28	30	32	34	35	38	40
72,0		5	5	5	7	7	8	9	10	10	14	15	15	19	20	21	23	25	26	28	30	31	32	35	36
78,0		4	5	5	6	7	7	9	9	9	13	14	14	17	18	19	22	23	24	26	27	28	30	32	33
84,0		4	4	4	6	6	7	8	9	9	12	13	13	16	17	18	20	21	22	24	26	26	28	30	31
90,0		4	4	4	6	6	6	8	8	8	12	12	12	15	16	16	19	20	20	23	24	25	27	28	29
96,0		4	4	4	5	6	6	7	8	8	11	11	12	15	15	15	18	19	19	22	23	23	26	26	27
102,0		3	4	4	5	5	5	7	7	7	10	11	11	14	14	15	17	18	18	21	22	22	24	25	26
108,0		3	3	3	5	5	5	7	7	7	10	10	10	13	14	14	17	17	17	20	21	21	24	24	24
114,0		3	3	3	5	5	5	6	7	7	10	10	10	13	13	13	16	17	17	19	20	20	23	23	23
120,0		3	3	3	5	5	5	6	6	6	9	10	10	13	13	13	16	16	16	19	19	19	22	22	23

Bilaga 2. Tabell resultat beräkning av dödlighet vid passage genom ny turbin.

Beräknad dödlighet (%) pga turbinbladsträff NY turbin																									
Fisklängd (cm):		10			15			20			30			40			50			60			70		
Turbinvatten-föring (m^3/s)		25% - p	median	75% - p	25% - p	median	75% - p	25% - p	median	75% - p	25% - p	median	75% - p	25% - p	median	75% - p	25% - p	median	75% - p	25% - p	median	75% - p	25% - p	median	75% - p
48,1		5	6	6	8	9	9	11	12	12	16	18	19	21	24	25	26	30	31	32	37	37	37	43	44
56,1		5	5	5	7	8	8	9	10	10	14	15	16	18	20	21	23	25	26	27	30	31	32	35	37
64,1		4	4	5	6	7	7	8	9	9	12	13	14	16	17	18	20	22	23	24	26	27	28	30	32
72,1		4	4	4	5	6	6	7	8	8	11	11	12	14	15	16	18	19	20	21	23	24	25	27	28
80,1		3	3	4	5	5	5	6	7	7	10	10	11	13	14	14	16	17	18	19	20	21	23	24	25
88,0		3	3	3	4	5	5	6	6	6	9	9	10	12	12	13	15	15	16	18	19	19	21	22	22
96,0		3	3	3	4	4	4	5	6	6	8	9	9	11	11	12	14	14	14	16	17	17	19	20	20
104,0		3	3	3	4	4	4	5	5	5	8	8	8	10	10	11	13	13	13	15	16	16	18	18	19
112,0		2	2	2	4	4	4	5	5	5	7	7	7	10	10	10	12	12	12	14	15	15	17	17	17
120,0		2	2	2	3	3	3	5	5	5	7	7	7	9	9	9	11	11	12	14	14	14	16	16	16
128,0		2	2	2	3	3	3	4	4	4	6	7	7	9	9	9	11	11	11	13	13	13	15	15	15
136,0		2	2	2	3	3	3	4	4	4	6	6	6	8	8	8	10	10	10	12	12	12	14	14	15
144,0		2	2	2	3	3	3	4	4	4	6	6	6	8	8	8	10	10	10	12	12	12	14	14	14
152,0		2	2	2	3	3	3	4	4	4	6	6	6	7	8	8	9	9	9	11	11	11	13	13	13
160,0		2	2	2	3	3	3	4	4	4	5	5	5	7	7	7	9	9	9	11	11	11	13	13	13

Bilaga 3. Figurer jämförelse av beräknad dödlighet vid passage genom befintlig- och ny turbin.



Figur 1. Jämförelse av beräknad dödlighet p.g.a. turbinbladsträff vid passage genom befintlig- och ny turbin i Klosterfoss. Punkter avser medianvärden och staplar avser värden för 25- och 75%-percentilen.

Bilaga 4. Turbindata använda vid beräkning av fiskdödlighet vid turbinpassage.

Turbindata Klosterfoss				
Betckning	**"Befintliga turbiner"**		**"Nya turbiner"**	
nr	**1**	**2**	**1**	**2**
Turbintyp	Rörturbin	Rörturbin	Rörturbin	Rörturbin
Slukförmåga/max vannføring (m^3/s)	120	120	160	160
Ytterdiameter (m)	4,5	4,5	4,506	4,506
Navdiameter (m)	1,575	1,575	1,575	1,575
Varvtal (varv/minut)	85,7	85,7	100	100
Antal turbinblad	4	4	3	3

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