JOINT COOPERATION PROGRAMME

Component C3:

Lowland / Peatland subsidence – Future drainability

Document C3.3

PPPs fourth workshop on *Peatland subsidence and flooding modelling*

Banjarmasin

8-11 October 2012

Project: 1201430.000

Client: Water Mondiaal
Partners for Water
Royal Netherlands Embassy in Jakarta

Period: January 2011 – March 2013

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Koninklijk Nederlands Meteorologisch Instituut
Ministerie van Verkeer en Waterstaat

Deltares
Enabling Delta Life

Joint Cooperation Program (JCP)
2011 – 2015

Workshop subsidence, emission and water management

Banjarmasin

October 8-11, 2012

Program

Monday	- water management, lock
Tuesday	- emission modelling
Wednesday	- use of bulk density
Thursday	- analysis of PusAir monitoring results

Program Monday

10.00	Start workshop
	Criteria for design and location selection for lock
10.30	Presentation if ideas by PusAir
11.00	Presentation of ideas by Dedi Mulyadi
12.00	Lunch
13.00	Discus design and location

Program Tuesday

9.00	Presentation report from july workshop by PusAir
10.00	Discussion of topics raised
11.00	Further work on emission modelling
12.00	Lunch
13.00	Further work on emission modelling

Program Wednesday

9.00	Presentation by Marnix on use of bulk density measurements for subisdence and emission estimation
10.00	Exercise using bulk density
12.00	Lunch
13.00	Continuation of exercise

Program Thursday

9.00	Presentation by PusAir on Sei Ahas monitoring results
10.00	Analysis of monitoring results and comparison with literature and KFCP
12.00	Lunch
13.00	Discussion of Sei Ahas monitoring and planning of activities

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10.00	Start workshop
	Criteria for design and location selection for lock
10.30	Presentation of ideas by PusAir
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Design criteria

- Operated by single farmer
- Community maintenance
- Using local material
- Low technological level
- Reliable and robust in long term
- Not too much disturbed (farming)
- Not too heavy
- Preferably not possible to open both gates

Location criteria

- Outside KFCP canal blocking area
- Agreed by communities
- In a canal used by boats, but not too much
- On shallow peat
- Raise upstream canal water level

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Read and discus

Biogeosciences, 9, 1053–1071, 2012
www.biogeosciences.net/9/1053/2012/
doi:10.5194/bg-9-1053-2012

Biogeosciences

Subsidence and carbon loss in drained tropical peatlands

A. Hooijer[1], S. Page[2], J. Jauhiainen[3], W. A. Lee[4], X. X. Lu[5], A. Idris[6], and G. Anshari[7]
[1]Deltares, P.O. Box 177, Delft 2600 MH, The Netherlands
[2]Department of Geography, University of Leicester, UK
[3]Department of Forest Sciences, University of Helsinki, Finland
[4]Singapore Delft Water Alliance, National University of Singapore, Singapore
[5]Department of Geography, National University of Singapore, Singapore
[6]University of Jambi, Jambi, Indonesia
[7]Center for Wetlands People and Biodiversity, Tanjungpura University, Pontianak, Indonesia

Emission calculation

- Digital Elevation Model
- Peat depth measurements → peat map
- Groundwater depth → subsidence rate
- % oxiditation → CO_2 emission

Program Wednesday

9.00	Presentation by Marnix on use of bulk density measurements for subisdence and emission estimation
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Forms of subsidence

- Oxidation - biochemical
- Compaction - mechanical above GWL
- Consolidation - mechanical below GWL
- (Fire)

Bulk density

Mass per unit of volume

Dry bulk density – without water

g/cm^3 or kg/dm^3 or ton/m^3

difficult to get samples with undisturbed volume

Subsidence impact on dry BD

- Oxidation → limited
- Compaction → increase above GWL
- Consolidation → increase below GWL
- Fire → limited

Forms of subsidence

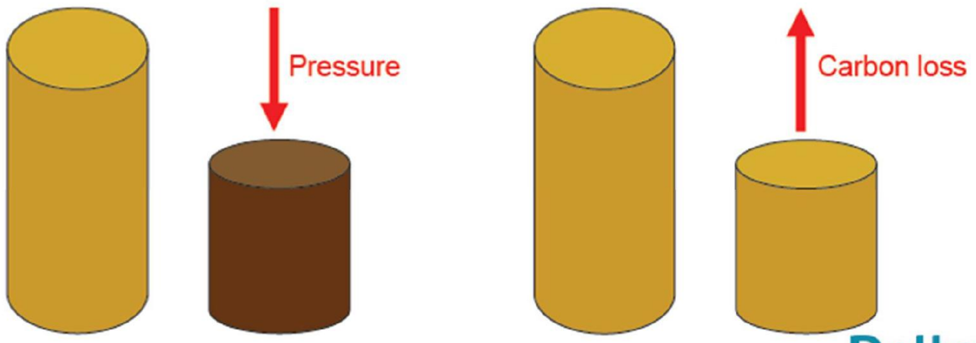
Compaction / consolidation: physical: the peat is compressed, volume reduced, bulk density goes up but mass remains the same.

Compaction

Before	After
Height: 10 cm	*Height: 5 cm*
Weigth: 1 kg	*Weigth: 1 kg*
BD: 0.1 g/cm^3	*BD: 0.2 g/cm^3*

Oxidation

Before	After
Height: 10 cm	*Height: 5 cm*
Weigth: 1 kg	*Weigth: 0.5 kg*
BD: 0.1 g/cm^3	*BD: 0.1 g/cm^3*



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Forms of subsidence

There are two groups oif processes that are fundamentally different

Compaction and consolidation are **physical**: the peat is compressed, volume reduced, bulk density goes up but mass remains the same.

Oxidation is **biological / chemical**: the peat is decomposed by organisms, volume is reduced, bulk density remains the same but mass is lost.

WE NOTICE THEY ARE OFTEN CONFUSED

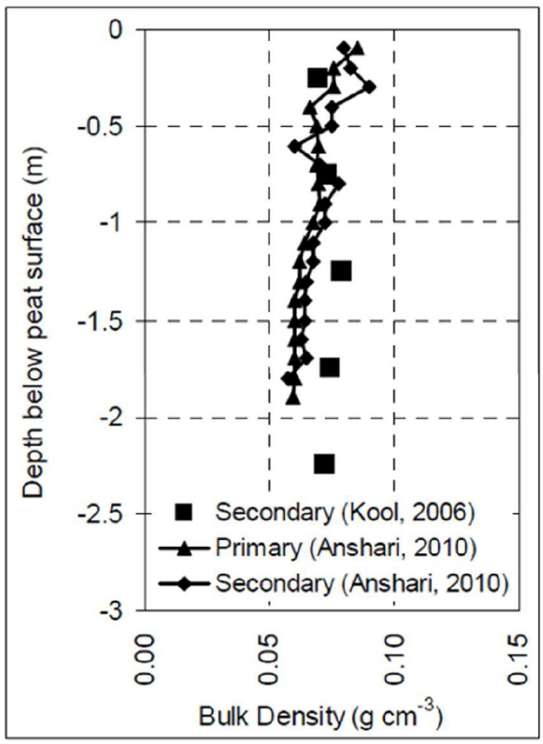
IF STANDARD SOIL-ENGINEERING EQUATIONS ARE USED TO EXPLAIN SUBSIDENCE IN PEATLANDS, THE RESULTS WILL MEANINGLESS AND INACCURATE.

APPLYING STANDARD EQUATIONS TO PEAT SUBSIDENCE IGNORES THE LOSS OF PEAT MATTER, AND THEFORE THE CO2 EMISSION

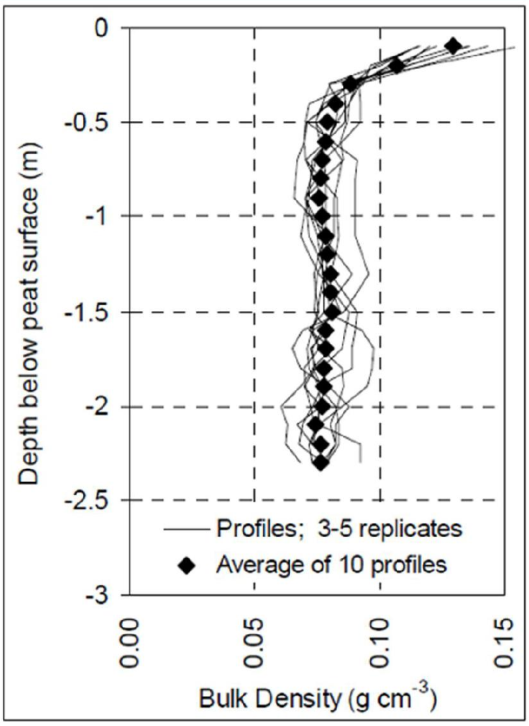
Deltares

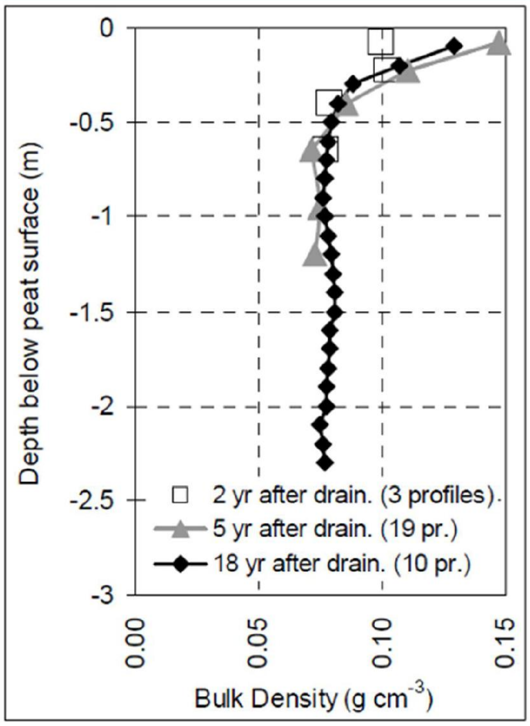
BD in natural situation

Constant with depth



BD in drained plantation





2.5 Determining the compaction component of subsidence

The contribution of compaction (including shrinkage) and oxidation to subsidence was calculated by determining the net increase in BD of the peat above the water table caused by compaction, and the total amount of subsidence in that period (e.g. Stephens and Speir, 1969; Schothorst, 1972; Ewing and Vepraskas, 2006; Leifeld et al., 2011). We used a variation modified from Driessen and Soepraptohardjo (1974), as follows:

$$V_{ox} = ((V_1 \times BD_1) - (V_{rest} \times BD_2))/BD_1$$

and:

$$V_{comp} = V_{rest} \times (BD_2 - BD_1)/BD_1$$

and:

$$P_{ox} = V_{ox} \times BD_1 / \left((V_{ox} \times BD_1) + (V_{comp} \times BD_1)\right)$$

where:

- V_{ox} = peat volume loss due to oxidation (cm^3),
- V_{comp} = volume loss due to compaction (cm^3),
- V_{rest} = peat volume after subsidence, above deepest groundwater level (cm^3),
- V_1 = peat volume before subsidence, above deepest groundwater level (cm^3),
- BD_1 = original bulk density above deepest groundwater level ($g\ cm^{-3}$),
- BD_2 = new bulk density above deepest groundwater level, after subsidence ($g\ cm^{-3}$),
- P_{ox} = percentage of subsidence caused by oxidation.

Calculate subsidence from BD

- Only for mechanical subsidence (compaction and consolidation, NOT oxidation)
- Calculate the factor of increase of BD
- Calculate original depth of soil column

BD1=0.07 g/cm3 BD2=0.14 g/m3

thick=1m

original peath thickness 2m

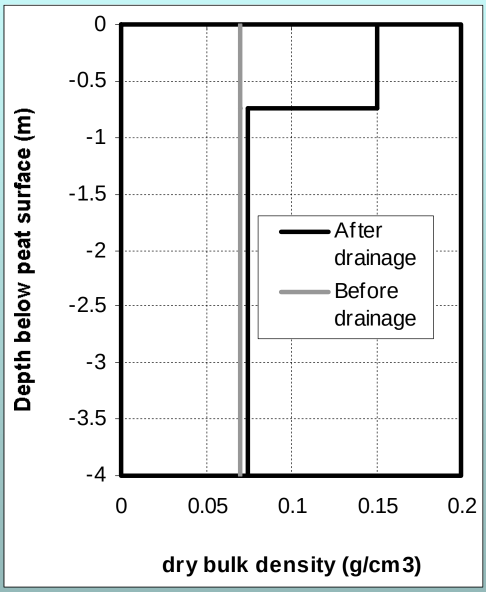
Exercise 1

- Original BD 0.07 g/cm^3
- Total subsidence 1.5m
- After drainage BD:

  0-75cm 0.15

  75-400cm 0.075

- Calculate subsidence due to compaction / consolidation and % oxidation.



Answer to exercise 1

Top 0.75m:
BD factor=0.15/0.07=2.1
Original depth=2.1*0.75=1.61m
Bottom 3.25m:
BD factor=0.075/0.07=1.07
Original depth=1.07*3.25=3.48m
Original total depth=1.61+3.48=5.09m
Subsidence=1.09m
%oxidation=(1.5-1.09)/1.5=27%

Exercise 2

- Actual peat thickness 8.4m
- Total subsidence 142cm in 5 years
- Consolidation 56cm in first year
- Average GWD 75cm
- BD above GW 0.09 and below GW 0.075 g/cm^3

- Calculate original BD from consolidation
- Calculate amount of compaction
- Calculate % of subsidence due to oxidation
- Calculate average annual CO2 emission/ha

Answers to exercise 2

Consolidation:

BD factor below GW=(8.4+0.56-0.75)/(8.4-0.56)=1.07

Original BD=0.075/1.07=0.070 g/cm^3

Answers to exercise 2

Compaction

BD factor above GW=0.09/0.07=1.29

Original depth=0.75*1.29=0.97m

Susidence due to compaction=
0.97-0.75=0.22m

Answers to exercise 2

% Oxidation

Total subsidence=142cm

Consolidation=56cm

Compaction=22cm

Oxidation=64cm

%Oxidation = 64/142=45%

Answers to exercise 2

Average annual CO_2 emission per hectare

Subsidence due to oxidation=64cm in 5 year

=13cm/y

Weight=0.13*10^4*0.075=97 ton/ha/y

Carbon weight=50%*07=48tonC/ha/y

Emission = 3.66*48=177tonCO_2/ha/y

WATER MANAGEMENT TO MITIGATE PEATLAND DEGRADATION

(Adaptive Strategic for Sustainable Peatland Management)

L. Budi Triadi

Balai Rawa – Puslitbang SDA

BALITBANG PU

Banjarmasin, 8 Oktober 2012

KEMENTRIAN PEKERJAAN UMUM

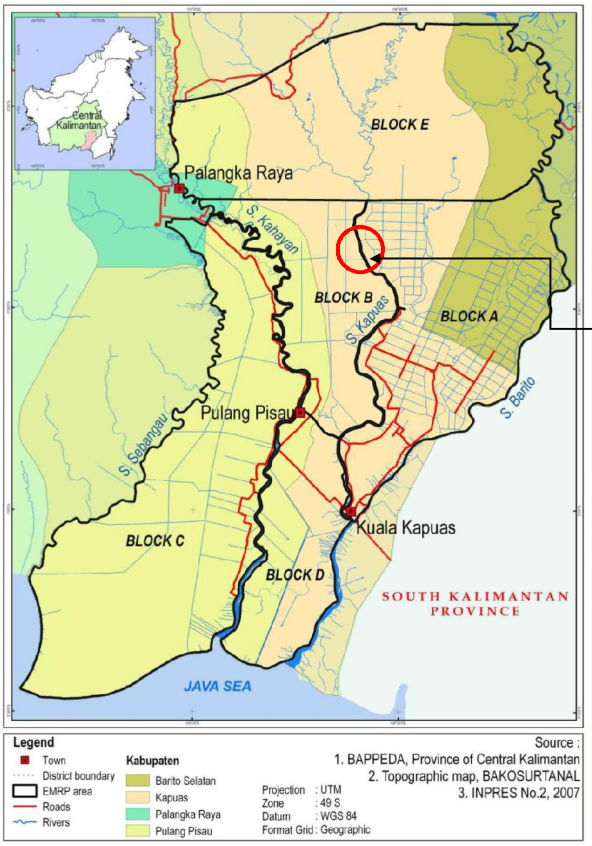
BADAN PENELITIAN DAN PENGEMBANGAN

PUSAT PENELITIAN DAN PENGEMBANGAN SUMBER DAYA AIR

BALAI RAWA

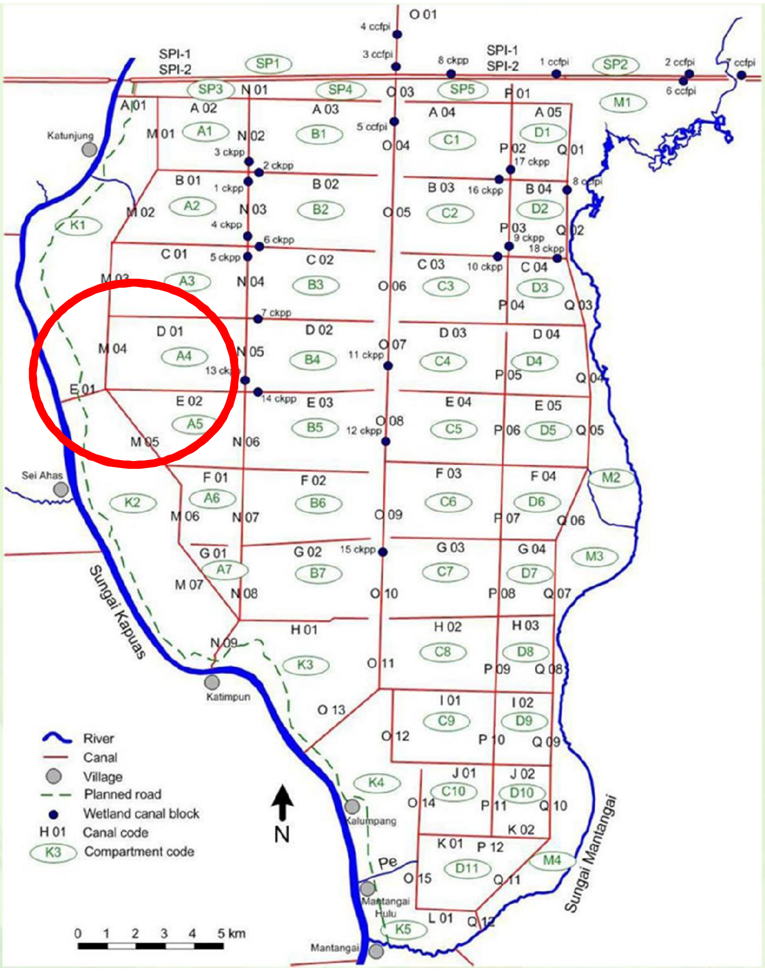
Jl. Gatot Subroto No. 6 Rt. 34 Telp. (0511) 3252029 Fax. (0511) 3256623 BANJARMASIN 70235

LOCATION OF THE STUDY



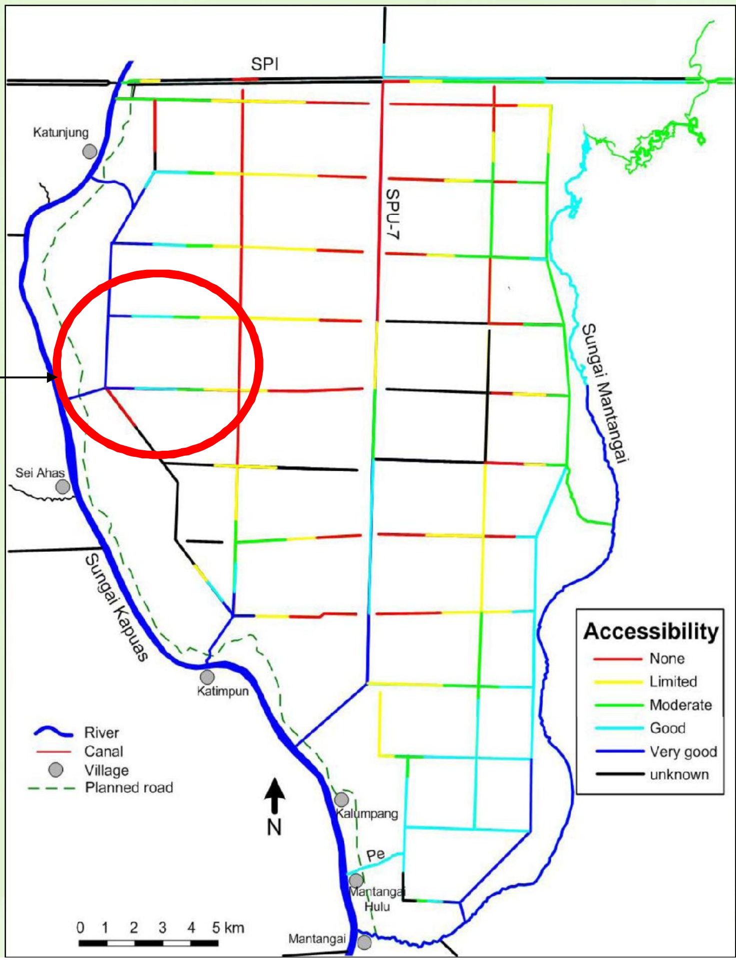
- Sei Ahas, Mentangai, Kapuas, Central Kalimantan
- Adaptif Management Zone
- Peat Depth ≤ 3 m

SOURCE : KFCP – HRDM 2010

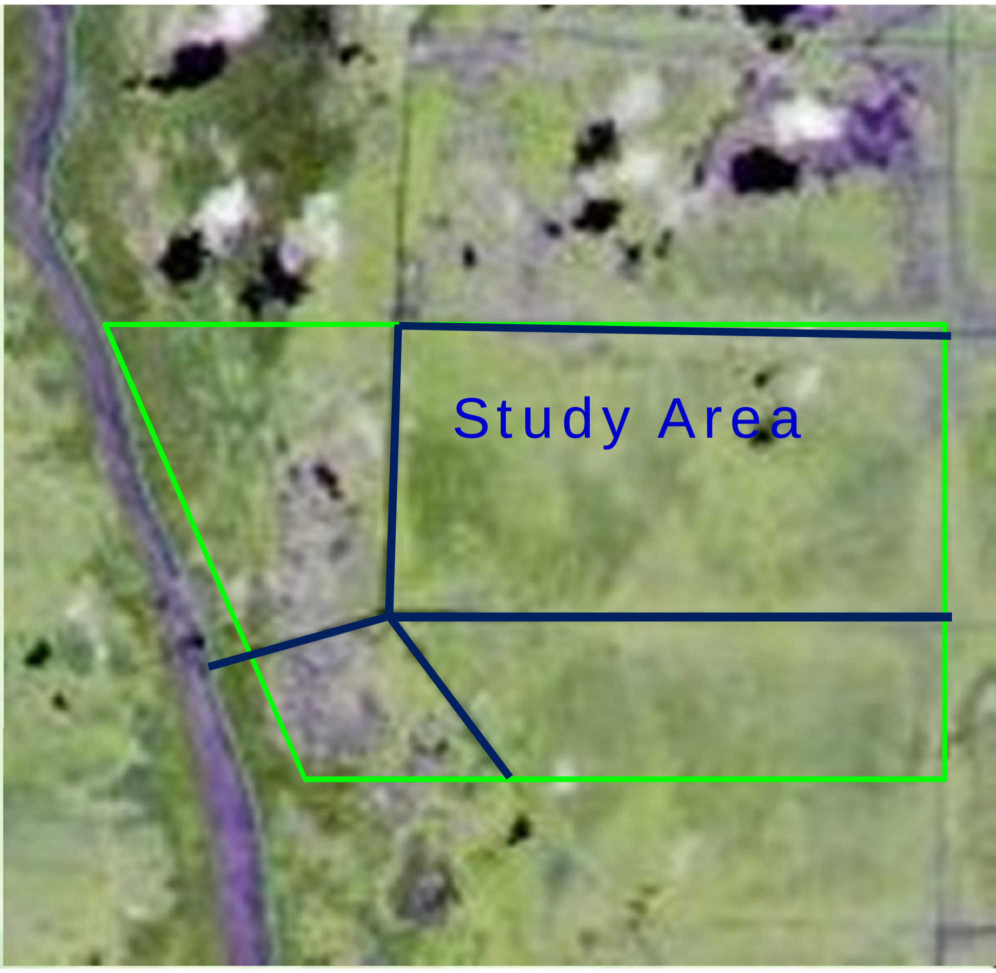


SOURCE :
KFCP – HRDM
2010

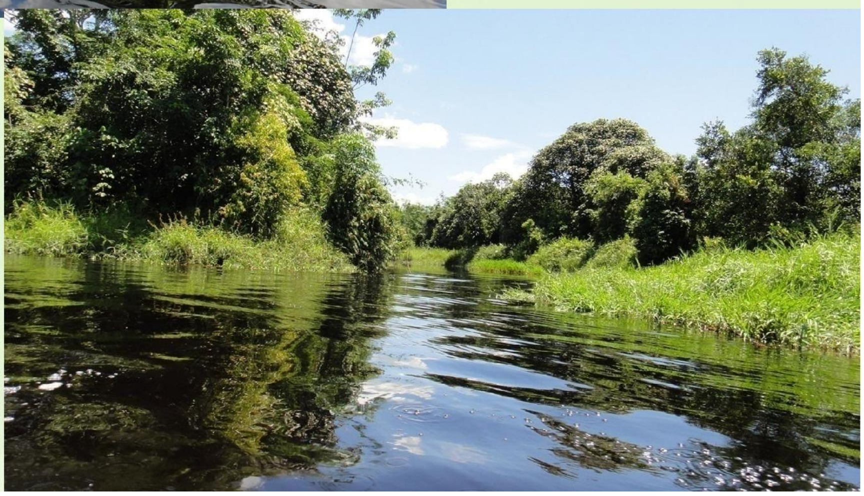
Sei. Ahas



SOURCE :
KFCP – HRDM
2010


Study Area



OBJECTIVE

To maintain water in peatland from excessive drainage caused by many and large canals in EMRP

Targets ???

- Restoring degraded peatlands slowly back to natural forest / adaptive agriculture land
- Provide water to the community
- Reduce fires
- Preventing peat continue to fall (subsidence)→ flood

Benefit

- Farmers can cultivate and grow peatlands that have been opened (degraded) into adaptive farmland
- Degraded peat lands back into forests

HOW ?

To elevate peatland ground water table :

- Build up canal blocking in the canal with no navigation

- Build up canal blocking with ship lock in the canal with navigation

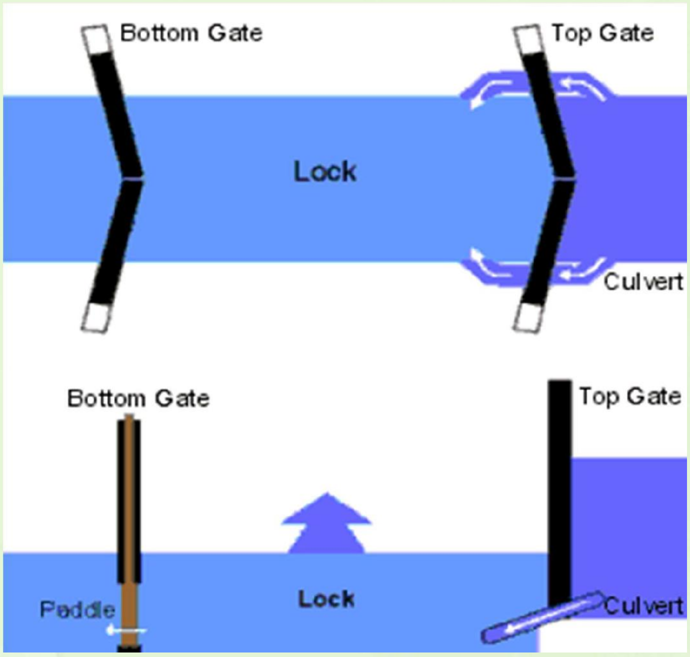
COMPACTED PEAT DAM

Note : Width ± 8 – 15 m & crest elevation 1,5 m above surrounding peatland

13

Source KFCP - 2011

SHIP LOCK / BOAT PASSAGE



HOW IT WORKS ?

BOAT TO UPSTREAM

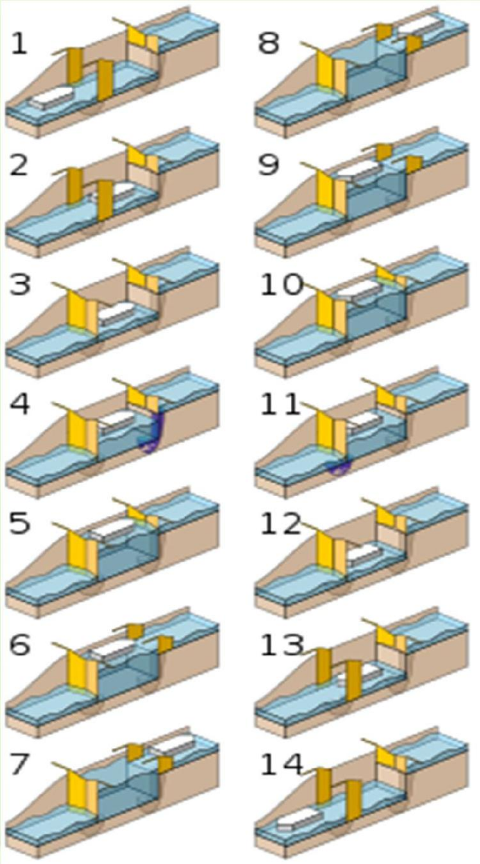
1–2.
Boat enter

3.
Downstram gate is closed

4–5.
Pond is filling from upstream

6.
Upstream gate is open

7.
Boat out of the pond



BOAT TO DOWNSTREAM

8–9.
Boat enter

10.
Upstream gate is closed

11–12.
Pond is emptying from downstream

13.
Downstram gate is open

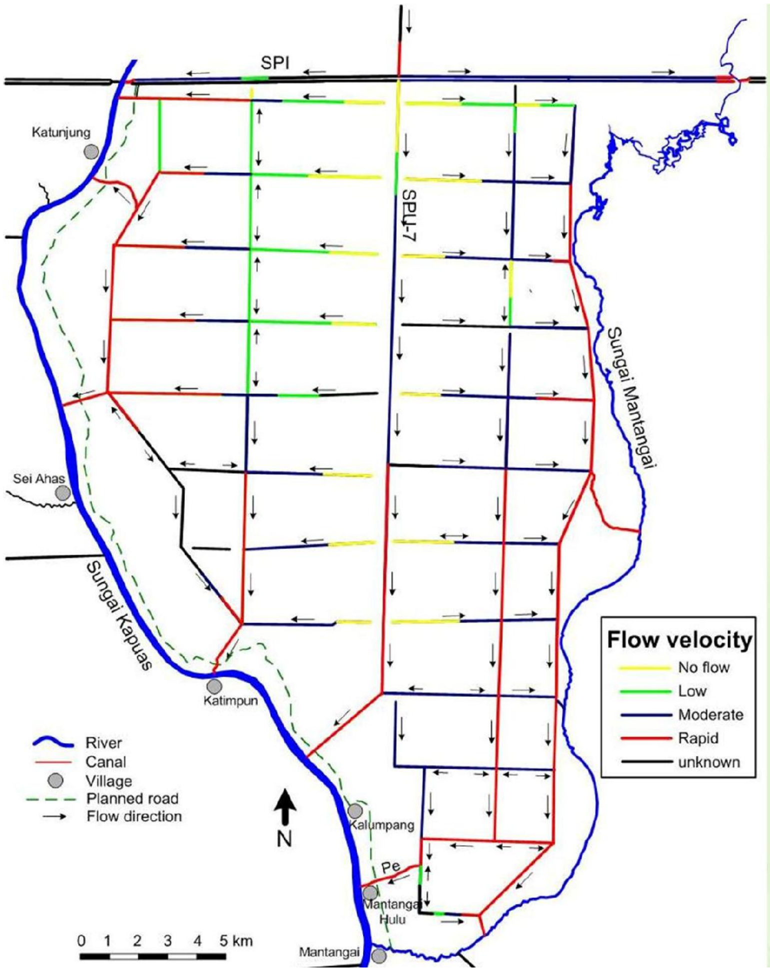
14.
Boat out of the pond

The shiplocks should be built in ways, and with materials, that :

- Allow a single farmer in a small boat to operate it, and a community to maintain.
- It all needs to be very simple and low-tech,
- Using local materials,
- Reliable and robust (kuat) in the long term

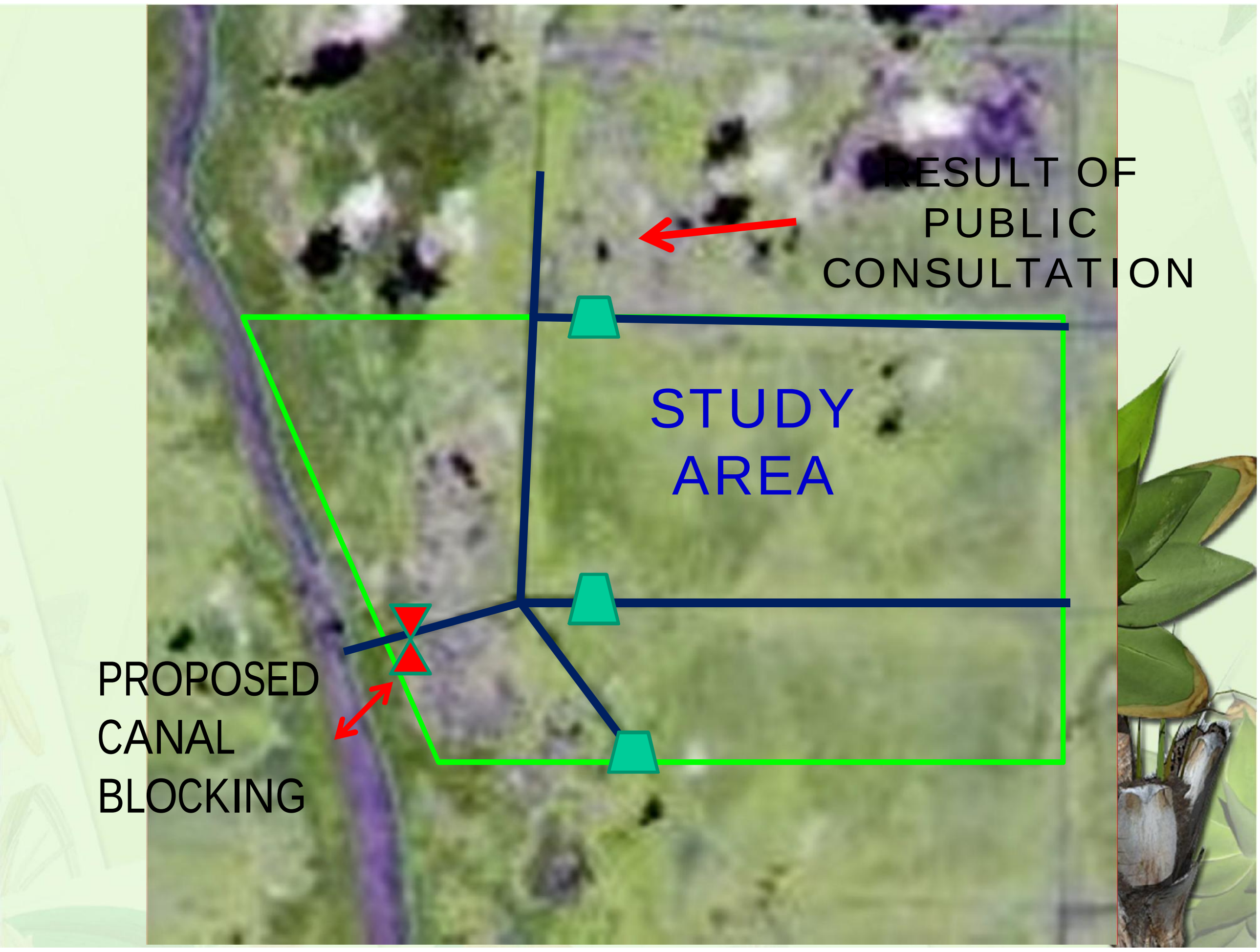
This probably excludes all concrete and steel type structures such as used in plantations, with a preference for wood and peat as the main building materials (cheap and easily replaced).

Model of early river pound lock, constructed in Lankheet water park, Netherlands



DIRECTION OF FLOW

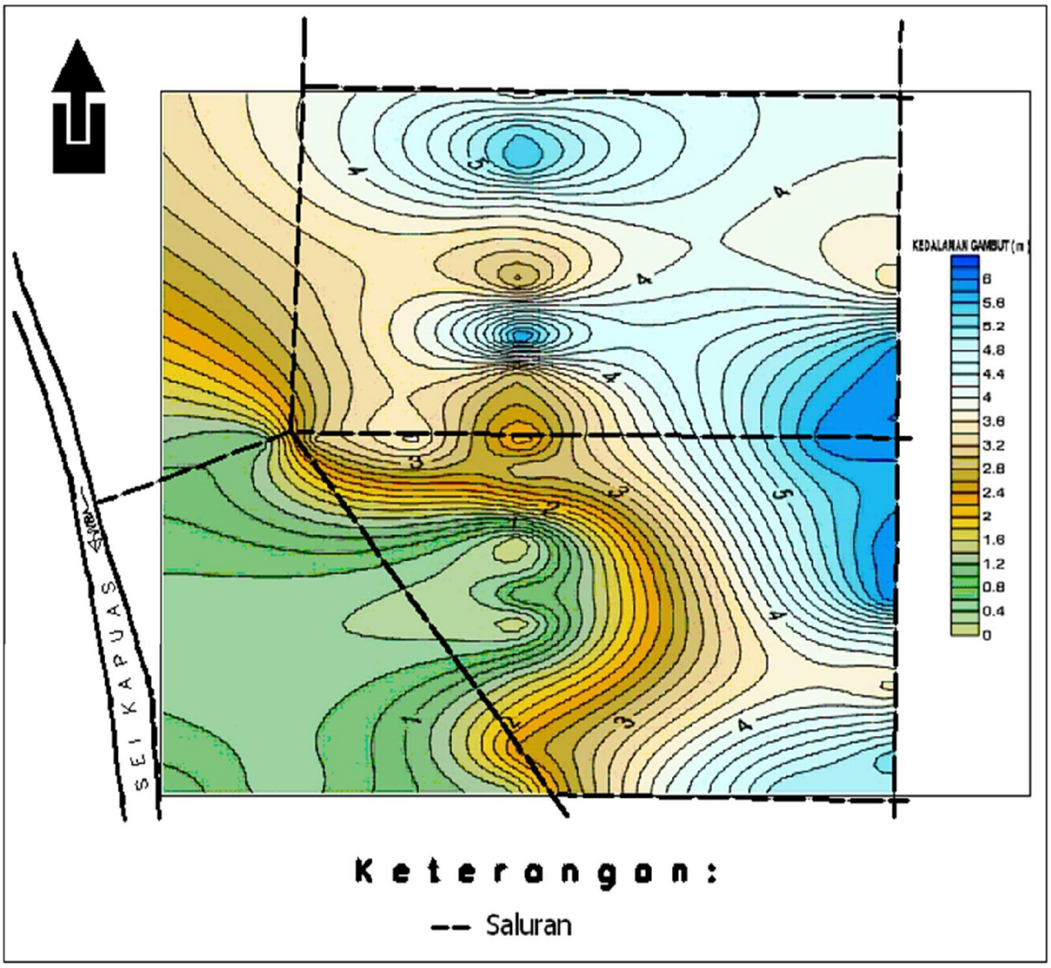
SOURCE : KFCP – HRDM 2010



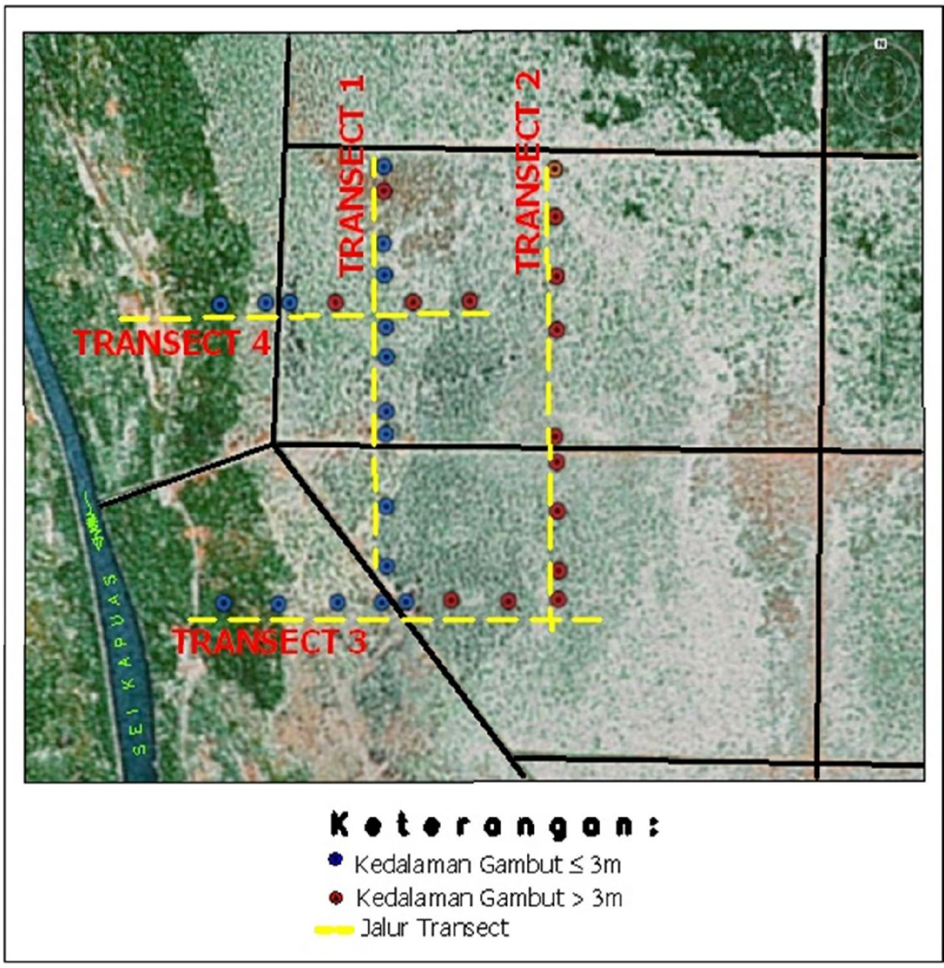
WM TEST

Reduce of *Subsidence*	• Subsidence Poles
Raise of GWT	• Dipwells
Reduce of carbon emission	• Computations

THANK YOU



PEAT DEPTH COUN TOUR



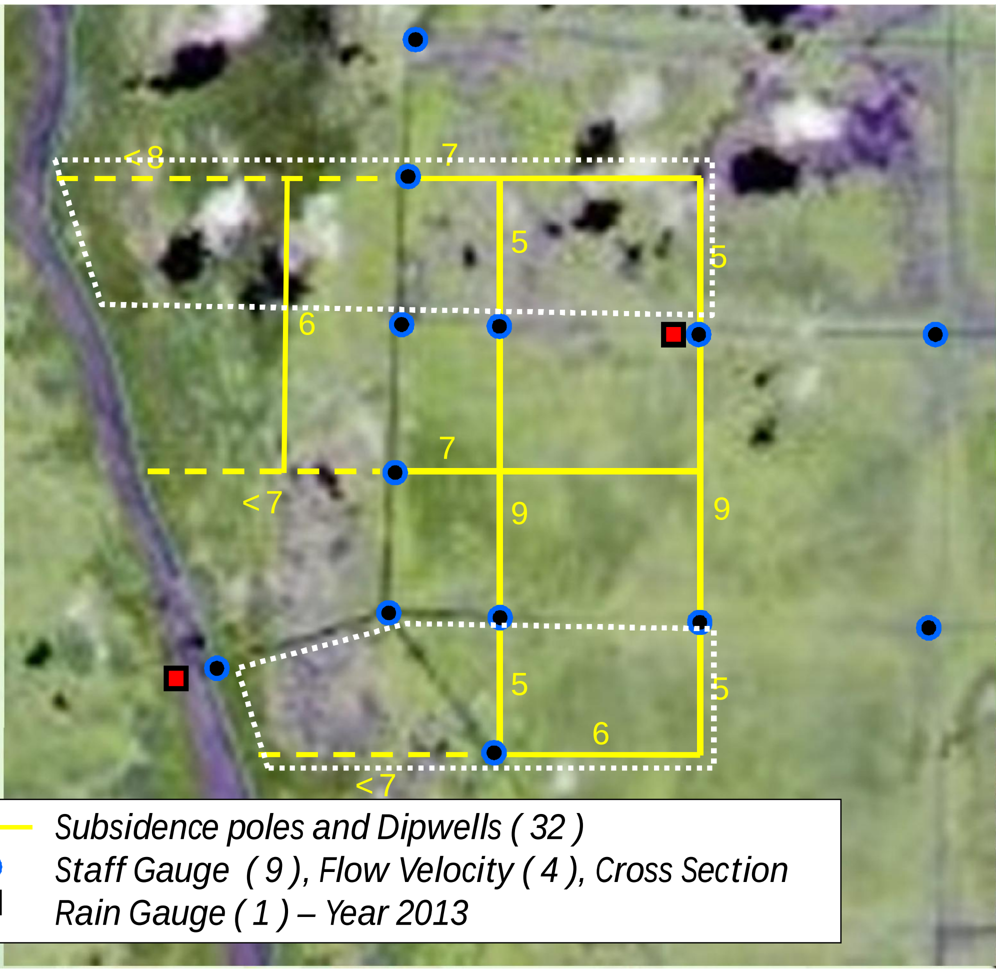
TRANSECT OF SUBSIDENCE POLES / DIPWELLS

Subsidence Poles

Sumber : KFCP – HRDM 2010

Dipwells

Sumber :
KFCP – HRDM
2010



CATATAN :

- Bendung terbuat dari tanah gambut (dari sekitar lokasi) yang dipadatkan untuk mengurangi rembesan.
- Untuk menghindari kebocoran dan kerusakan, tubuh bendung harus cukup panjang (8 – 15 m tergantung lebar saluran) dengan elevasi puncak (sesudah dipadatkan) minimum 1,5m di atas permukaan tanah di sekitarnya supaya tidak dapat dilewati air banjir (mencegah erosi dan penurunan).
- Perbedaan elevasi muka air hulu dn hilir harus dipertahankan kecil (0,2 m)
- Bendung dibangun secara mekanis (karena besar dan perlu pemadatan) dengan excavator dan dump truck

CONCLUSION :

- Max & Min WL and Q are required
- Gates without culverts
- Gates are equipped with gear + paddle, sills are not necessary
- Lock chamber wall : gelam wood to protect soil from sliding
- 1 gate downsteram, 1 gate upstream
- Sliding gate from wood (Blangiran)
- Floor from wood (Blangiran)
- Locations free from disturbance
- Trash trap is not required
- Operator is not required to operate & maintenance ; commitment ?

- Lock in side channel
- Length of canal blocking ≥ width of canal
- Automatically close and open gate (not electric one)
- The lock location is at the middle of side canal
- The material is not steel, concrete or sand, because too heavy
- Foundation is made of cerucuk / gelam poles
- Build one by one and evaluate each time
- The construction cost should be cheap and life time less than 7 years
- Land acquisition ? BWS Kal II

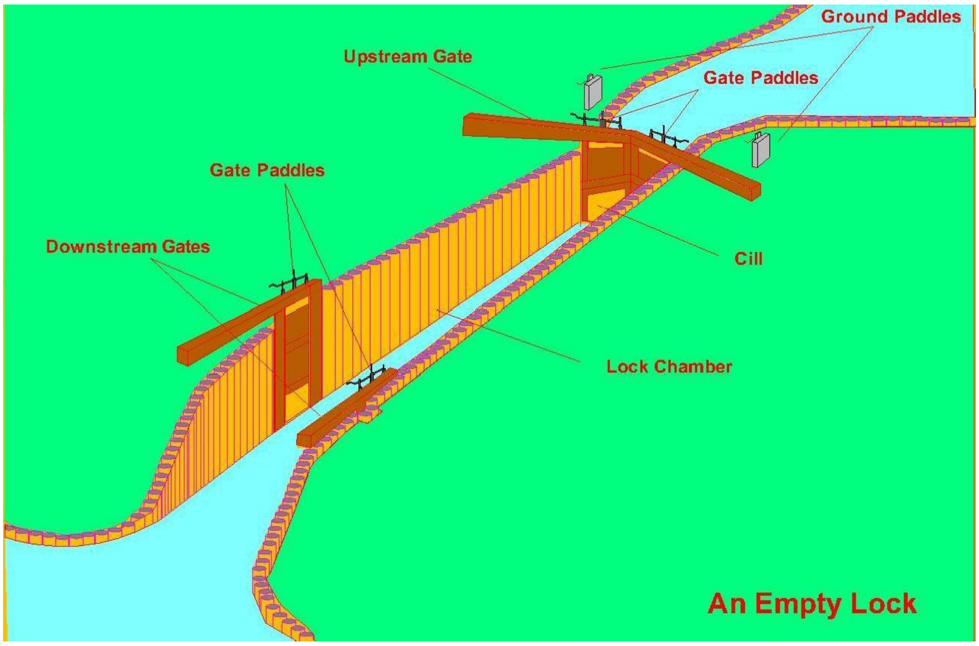
-

CANAL LOCK SYSTEM

Canal Lock system is a chamber with gates at both ends, allowed boats to move between different water levels.

Lock chamber with gates at both ends, set the water level in accordance with the purposes: raising the water level to the upstream level and or lowering the water level to the downstream level.

CANAL LOCK COMPONENTS



Ground Paddles

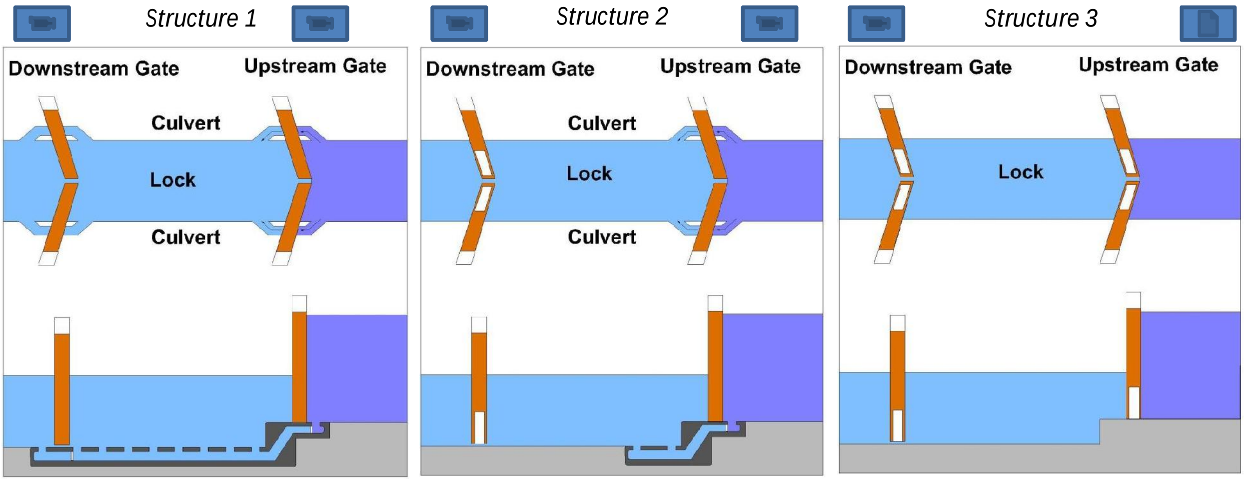
Lock Chamber

Cill

Gate Paddles

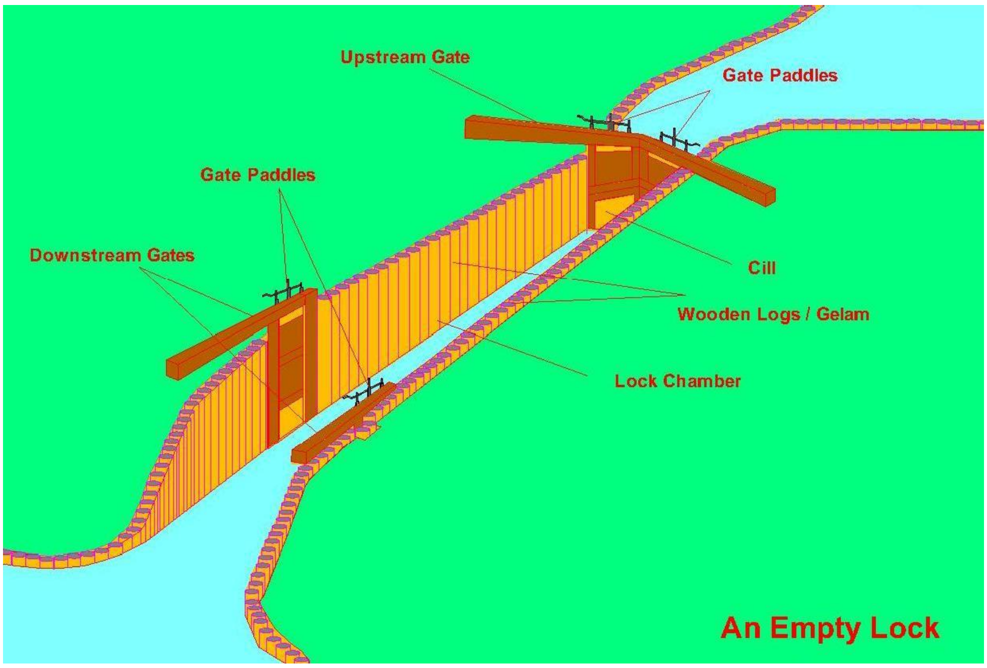
Gates

CANAL LOCK STRUCTURES



in terms of water control structures, divided into 3 structure as follows: (1) fully controlled using the culvert on the floor of the structure, (2) controlled by a combination of culverts and gates, (3) controlled entirely by the two gates.

APPLICATION OF CANAL LOCK IN THE PEATLANDS



Lock Chamber built by some Gelam wood driven to mineral soil along the canal walls, with an average diameter of wood required is 15 till 20 cm.

CANAL LOCK IMPLEMENTED IN THE PEATLANDS PLANTATION

- Gates often stalled because a lot of woody debris (trash trap is needed, it should be controlled and maintained on a regular basis)
- canal floor around gates easily eroded by the waterfall (the floor needs to be protected by wooden material)
- Landslides and erosion around the gates, locks canal should be built in a location that has not been disturbed.

CANAL LOCK IMPLEMENTED IN THE PEATLANDS PLANTATION

CANAL LOCK DESIGN FOR SEI AHAS

- The type of canal locks structure selected in accordance with the conditions of peat that is controlled entirely from both gates (without culverts), and each gates equipped with cill.
- Cill (equipped with gears and gate paddles) are made of steel plate with size adjusted to the needs.
- Lock Chamber maximum sized 10x2 m, enough to pass a kelotok.
- With a width of 2 m, each gate will be enough with one door only.
- Gate made from local wood that is water resistance such as "blangiran".
- Lock Chamber covered by some gelam wood with a diameter of 15-20 cm, pushed to the mineral soil minimum 2 m, along the canal wall around the structure.
- The floor around the gates covered by wood beams that water resistant such as blangiran to protect the floor from the scouring of water when gates opened and closed.
- To reduce erosion around the structure of the canal lock, the location should be selected that has not been disturbed.
- Required the trash or debris trapper to anticipate stuck gates.
- Required the operator to operate the canal lock and to maintain it.

Design criteria

- Operated by single farmer
- Community maintenance
- Using local material
- Low technological level
- Reliable and robust in long term
- Not too much disturbed (farming)
- Not too heavy
- Preferably not possible to open both gates

Location criteria

- Outside KFCP canal blocking area
- Agreed by communities
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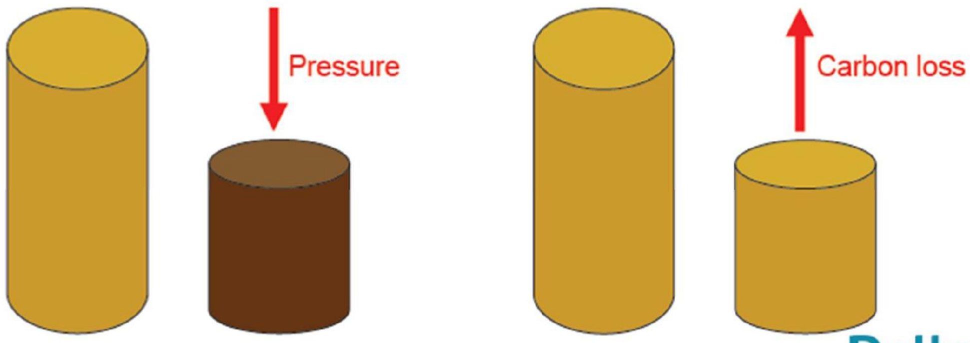

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Deltares

BD in natural situation

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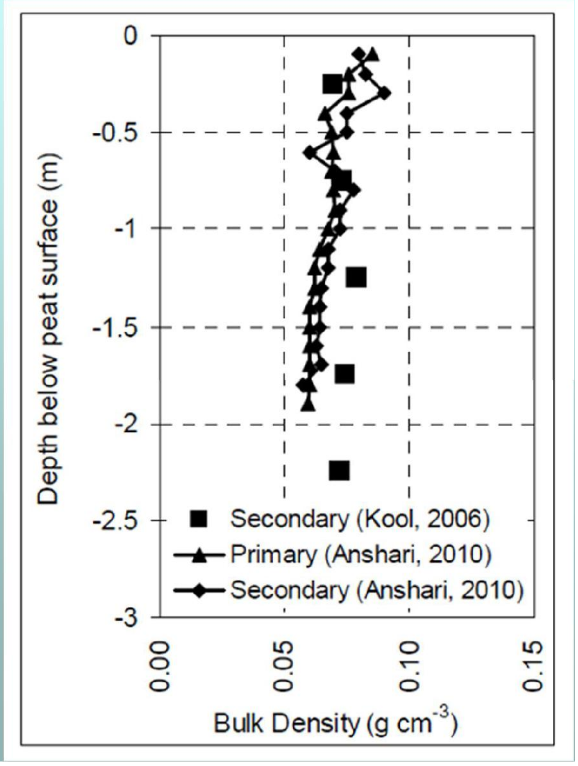
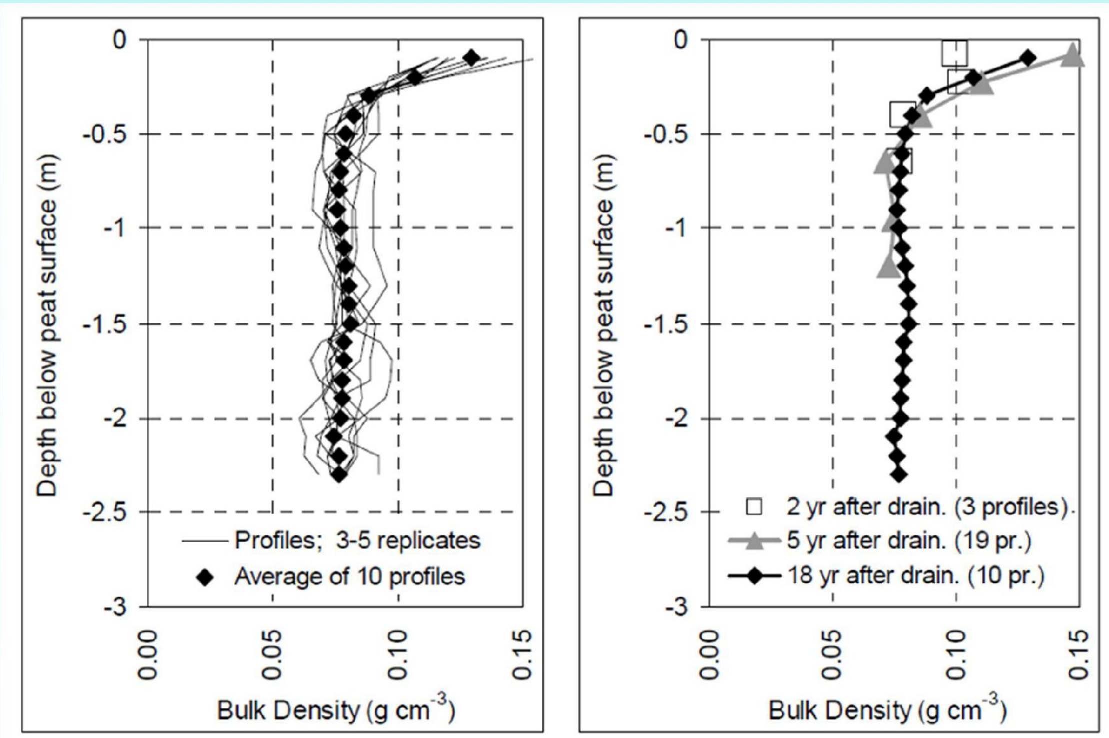


BD in drained plantation



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and:

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and:

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where:

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BD1=0.07 g/cm3 BD2=0.14 g/m3

thick=1m

original peath thickness 2m

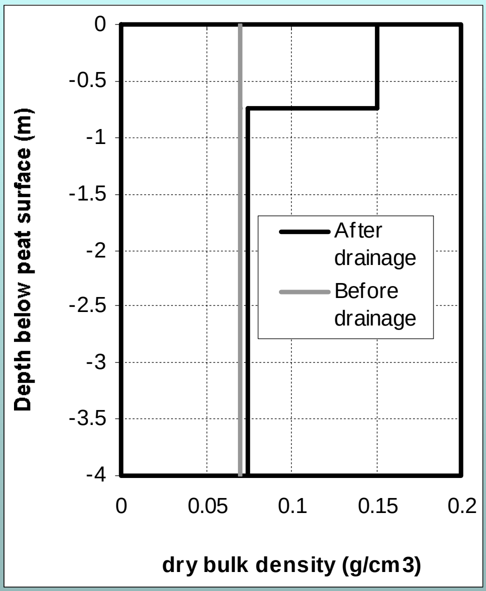
Exercise 1

- Original BD 0.07 g/cm^3
- Total subsidence 1.5m
- After drainage BD:

  0-75cm 0.15

  75-400cm 0.075

- Calculate subsidence due to compaction / consolidation and % oxidation.



Answer to exercise 1

Top 0.75m:

BD factor=0.15/0.07=2.1

Original depth=2.1*0.75=1.61m

Bottom 3.25m:

BD factor=0.075/0.07=1.07

Original depth=1.07*3.25=3.48m

Original total depth=1.61+3.48=5.09m

Subsidence=1.09m

%oxidation=(1.5-1.09)/1.5=27%

Exercise 2

- Actual peat thickness 8.4m
- Total subsidence 142cm in 5 years
- Consolidation 56cm in first year
- Average GWD 75cm
- BD above GW 0.09 and below GW 0.075 g/cm^3

- Calculate original BD from consolidation
- Calculate amount of compaction
- Calculate % of subsidence due to oxidation
- Calculate average annual CO2 emission/ha

Answers to exercise 2

Consolidation:

BD factor below GW=(8.4+0.56-0.75)/(8.4-0.56)=1.07

Original BD=0.075/1.07=0.070 g/cm^3

Answers to exercise 2

Compaction

BD factor above GW=0.09/0.07=1.29

Original depth=0.75*1.29=0.97m

Susidence due to compaction=
0.97-0.75=0.22m

Answers to exercise 2

% Oxidation

Total subsidence=142cm

Consolidation=56cm

Compaction=22cm

Oxidation=64cm

%Oxidation = 64/142=45%

Answers to exercise 2

Average annual CO_2 emission per hectare

Subsidence due to oxidation=64cm in 5 year

=13cm/y

Weight=$0.13*10^4*0.075$=97 ton/ha/y

Carbon weight=50%*07=48tonC/ha/y

Emission = 3.66*48=177tonCO_2/ha/y