SKB TR-10-02

The limnic ecosystems at Forsmark and Laxemar-Simpevarp

In the earlier distributed report, there are errors that have now been corrected. The corrected pages 384, 387, 388 and 389 are enclosed. The changed text is marked with a vertical line in the page margin. An updated pdf version of the report, dated 2011-10, can be found at www.skb.se/publications.

Aqu_dens_regoUp _acc (kg m⁻³)

Aqu_dens_regoUp _acc represents the dry bulk density of the upper sediment on accumulation bottoms in the limnic and marine areas, represented by soft organic sediment with very high water content (Table 11-3). The proportions of accumulation and erosion bottoms at each site/basin the marine area are based on the sedimentation model /Lindborg 2010/. In the isolated lake basins, the entire bottom area is regarded as accumulation bottom. The parameter values are based on measurements of the water content and organic carbon content of sediments from both limnic and coastal surface samples (Brunberg, unpublished data Table 11-5, /Hedenström 2004/). For the shallow marine area, measurements of the dry bulk density of the upper 10 cm of sediments were used (Table 11-4).

Aqu_poro_regoUp_acc (m³ m⁻³)

Aqu_poro_regoUp_acc represents the porosity of the upper sediment on accumulation bottoms in the limnic and marine areas, represented by soft organic sediment with very high water content. In the isolated lake basins (objects), the entire bottom area is regarded as accumulation bottom. The porosity values are based on measurements of the water content in surface sediment from 7 lakes at Forsmark (Table 11-5) and measurements of the water content and organic carbon content of lake sediments from the site investigations (Table 11-6). The formula for calculating porosity (n) is given below /Talme and Almén 1975/. Mean, minimum, and maximum values of porosity in the upper regolith are presented in Table 11-7.

$n = Vp/V$

Vp represents the volume of water, V represents the total volume
1 g/cm³ is used for the density of water and organic matter
2.65 g/cm³ is used for the density of the minerogenic fraction.

Table 11-3. Parameter values for Aqua_dens_regoUp_acc, representing the dry bulk density of the surface sediments in accumulation bottoms in the aquatic system in Forsmark.

Dry bulk dens	(kg m⁻³)
Mean	126
Max	220
Min	72
n	8

Table 11-4. Measured dry bulk density in Forsmark /Sternbeck et al. 2006/.

Site	Idcode	Depth (m)	Dry bulk dens. (kg m⁻³)
Tixelfjärden	PMF 005785	0.00–0.02	37.8
Tixelfjärden	PMF 005785	0.02–0.04	133.6
Tixelfjärden	PMF 005785	0.04–0.05	208.6
Tixelfjärden	PMF 005785	0.06–0.07	175.7
Tixelfjärden	PMF 005785	0.07–0.08	170.0
Kallrigafjärden	PMF 005784	0.00–0.02	90.3
Kallrigafjärden	PMF 005784	0.02–0.04	151.9
Kallrigafjärden	PMF 005784	0.04–0.05	205.9
Kallrigafjärden	PMF 005784	0.06–0.07	194.4
Kallrigafjärden	PMF 005784	0.08–0.09	174.7

Table 11-10. The parameter values of Aqu_dens_regoMid_PG and Ter_dens_regoMid_PG, representing the dry bulk density of postglacial gyttja and clay gyttja in Forsmark.

Dry bulk dens	(kg m⁻³)
Mean	138
max	256
min	72
Std	38
n	12

Aqu_poro_regoMid_PG (m³ m⁻³)

Aqu_poro_regoMid_PG represents the porosity of the organic postglacial sediments, i.e. gyttja and clay gyttja, found in the limnic and marine areas as well as under the peat at mires. The values are based on measurements of the water content and organic content of gyttja and clay gyttja from the Forsmark site (Table 11-11) /Hedenström 2004, Hedenström and Risberg 2003, Nordén 2007/. The mean, maximum and minimum values are presented in Table 11-12.

Table 11-11. Input data used for calculations of the porosity of the postglacial sediments. */Hedenström 2004/, site-specific for each lake, ** /Hedenström and Risberg 2003/ Eckarfjärden, * /Nordén 2007/ site-specific but the water content of clay gyttja is based on values from Frisksjön, Laxemar-Simpevarp.**

Stratum/lake	Stratum thickness * (m)	C** (% of dw)	Water content*** (% of wet sample)	Dry bulk dens. kg m⁻³	Porosity (m³ m⁻³)
Eckarfjärden	(Σ 1.75 m)				
Gyttja	0.96	27	93	71.7	95.2
Clay gyttja	0.11	8	86****	152.2	93.5
Clay	0.68	1	53	662.0	74.6
Fiskarfjärden	(Σ 3.52 m)				
Gyttja	1	17	93	72.6	96.5
Clay gyttja	0.61	05	86****	152.7	93.8
Clay	1.91	1	53	661.7	74.6
Stocksjön	(Σ 0.49 m)				
Gyttja	0.4	27	86	149.5	91.8
Clay gyttja	0.03	8	86	152.2	93.5
Clay	0,06	1	53	662.0	74.6
Gällsboträsket	(Σ 1.41 m)				
Gyttja	0.34	27	86	149.5	91.8
Clay gyttja	0.37	8	86****	152.2	93.5
Clay	0.7	1	53	662.0	74.6
Bolundsfjärden	(Σ 0.6 m)				
Gyttja	0.48	27	90	104.8	94.3
Clay gyttja	0.07	8	86****	152.2	93.5
Clay	0.05	1	53	662.0	74.6
Puttan	(Σ 0.82 m)				
Gyttja	0.8	20	89	116.4	94.2
Clay gyttja	0.02	9	86****	152.1	93.4
Clay	0	1	53	661.7	74.6
N:a Bassängen	(Σ 0.16 m)				
Gyttja	0.15	27	86	149.5	91.8
Clay gyttja	0.01	8	86****	152.2	93.5
Clay	0	1	53	664.2	74.9

Table 11-12. Parameter values for Aqua_poro_regoMid_PG and Ter_poro_regoMid_PG, representing the porosity of postglacial gyttja and clay gyttja in Forsmark.

Porosity	m³ m⁻³
Mean	0.93
Max	0.96
Min	0.90
Std	0.02
n	7

Aqu_dens_regoMid_GL (kg m⁻³)

Aqu_dens_regoMid_GL represents the dry bulk density of the glacial clay found in both the limnic and marine areas. The values are based on calculations based on analyses of water content and organic carbon content in glacial clay from lakes /Hedenström 2004/. The mean, maximum and minimum values are presented in Table 11-13.

Aqu_poro_regoMid_GL (m³ m⁻³)

Aqu_poro_regoMid_GL represents the porosity of the glacial clay found in the limnic and marine areas. The porosity values for glacial clay are based on secondary calculations from grain-size distribution curves of clay collected offshore at Forsmark /Risberg 2005/ and calculations based on analyses of water content and organic carbon content in glacial clay from lakes /Hedenström 2004/. The mean, maximum and minimum values are presented in Table 11-14.

Lake_z_regoLow (m)

Lake_z_regoLow represents the total depth of the glacial till. The depth and distribution of this layer are constant over time, covering the bedrock surface from the deglaciation onwards. The depth of this layer is based on the RDM /Hedenström et al. 2008/. Mean values for the lake basin after isolation are used in the model. Mean, minimum and maximum values of the depth of the regoLow are presented in Table 11-15.

dens_regoLow (kg m⁻³)

The parameter dens_regoLow represents the dry bulk density of the deeper parts of the glacial till. The dry bulk density values for till are based on measurements from >0.3 m depth in the terrestrial area of the Forsmark site /Lundin et al. 2005, Sheppard et al. 2009/. Mean, minimum and maximum values of the density of the regoLow are presented in Table 11-16.

Table 11-13. Parameter values for Aqua_dens_regoMid_GL and Ter_dens_regoMid_GL, representing the dry bulk density of glacial clay in Forsmark.

Dry bulk dens	(kg m⁻³)
Mean	663
Max	664
Min	662
n	3

Table 11-14. Parameter values for Aqua_poro_regoMid_GL and Ter_poro_regoMid_GL, representing the porosity of glacial clay in Forsmark.

Porosity	(m³ m⁻³)
Mean	0.64
Max	0.75
Min	0.55
n	10

Table 11-15. Mean, minimum and maximum depth (m) of the lower regolith (z_regoLow) in the Forsmark objects. * In the case of objects 121_02 and 121_03, values are not initially defined but assumed from the depth of regoLow of the sea basin.

Object	mean	minimum	maximum
10	0.78	0.00	12.89
101	4.78	0.00	12.89
105	5.09	0.00	8.69
107	4.78	0.00	12.89
108	5.09	0.00	18.26
114	5.12	0.00	10.22
116	4.00	0.00	23.04
117	3.53	0.00	11.33
118	3.29	0.85	10.41
120	2.57	0.00	5.69
121_01	7.73	1.98	19.33
121_02	4.53*		
121_03	3.21*		
123	7.06	0.00	19.27
124	2.99	0.42	6.12
125	3.16	0.42	9.07
126	9.45	0.00	21.42
136	3.01	0.00	4.70

Table 11-16. Parameter values for dens_regoLow, representing the dry bulk density of till in Forsmark.

Dry bulk density	(kg m⁻³)

Dry bulk density	$(kg\ m^{-3})$
Mean	2,132
Max	2,200
Min	1,980
Std	87
N	5

poro_regoLow (m³ m⁻³)

The parameter poro_regoLow represents the porosity of the glacial till. The porosity values for till are based on measurements from >0.3 m depth in the terrestrial area of the Forsmark site /Lundin et al. 2005, Sheppard et al. 2009/. Mean, minimum and maximum values of the porosity of the regoLow are presented in Table 11-17.

Table 11-17. Parameter values for poro_regoLow, representing the porosity of till in Forsmark.

Porosity	$(m^3\ m^{-3})$
Mean	0.21
Max	0.27
Min	0.18
Std	0.04
n	4