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SITE NAME: **Struve Geodetic Arc**

DATE OF INSCRIPTION: 15th July 2005

STATE PARTY: BELARUS, ESTONIA, FINLAND, LATVIA, LITHUANIA, NORWAY, REPUBLIC OF MOLDOVA, RUSSIAN FEDERATION, SWEDEN, UKRAINE

CRITERIA: C (ii)(iv)(vi)

DECISION OF THE WORLD HERITAGE COMMITTEE:
Excerpt from the Decisions of the 29th Session of the World Heritage Committee

Criterion (ii): The first accurate measuring of a long segment of a meridian, helping in the establishment of the exact size and shape of the world exhibits an important step in the development of earth sciences. It is also an extraordinary example for interchange of human values in the form of scientific collaboration among scientists from different countries. It is at the same time an example for collaboration between monarchs of different powers, for a scientific cause.

Criterion (iv): The Struve Geodetic Arc is undoubtedly an outstanding example of technological ensemble – presenting the triangulation points of the measuring of the meridian, being the non movable and non tangible part of the measuring technology.

Criterion (vi): The measuring of the arc and its results are directly associated with men wondering about his world, its shape and size. It is linked with Sir Isaac Newton's theory that the world is not an exact sphere.

BRIEF DESCRIPTIONS

The Struve Arc is a chain of survey triangulations stretching from Hammerfest in Norway to the Black Sea, through ten countries and over 2,820km. These are points of a survey, carried out between 1816 and 1855 by the astronomer Friedrich Georg Wilhelm Struve, which represented the first accurate measuring of a long segment of a meridian. This helped establish the exact size and shape of our planet and marked an important step in the development of earth sciences and topographic mapping. It is an extraordinary example of scientific collaboration among scientists from different countries, and of collaboration between monarchs for a scientific cause. The original arc consisted of 258 main triangles with 265 main station points. The listed site includes 34 of the original station points, with different markings, i.e. a drilled hole in rock, iron cross, cairns, or built obelisks.

1.b State, Province or Region:

1.d Exact location: N55 54 09.0 E25 26 12.0

Nomination of the

STRUVE GEODETIC ARC

for inscription on the

WORLD HERITAGE LIST

Cover Illustration

The Frontispiece of *The Surveyor in foure bookes* by Aaron Rathborne, London 1616.

THE STRUVE GEODETIC ARC

Submission

to the

World Heritage Committee

for

Inscription

on the

World Heritage List

January 2004

Friedrich George Wilhelm Struve **(1793 - 1864)**

(Picture is a courtecy of Museum of Pulkova)

FOREWORD

The Struve Geodetic Arc was set up and measured from 1816 to 1855. The goal was to determine the dimensions of the Earth, its shape and size. Today the Arc spans through the territories of ten countries, i.e. Norway, Sweden, Finland, Russian Federation, Estonia, Latvia, Lithuania, Belarus, Republic of Moldova and Ukraine. It has also been the basis for mapping and land survey in many of these countries up to the mid 20th century.

The ten countries have worked together to preserve the Struve Geodetic Arc and contributed to the preparation of this documentation with a view to nominating the Struve Arc for inscription on the World Heritage List. The project has been coordinated by the National Land Survey of Finland. The National Survey Organisations in the countries have been in charge of the preparation under the supervision of the national Cultural Heritage Organisations. It is by this process that this document - "Nomination of the Struve Geodetic Arc for inscription on the World Heritage List" - was prepared according to the guidelines of the World Heritage Centre.

Many international organisations, such as the International Federation of Surveyors, the International Association of Geodesy, the International Astronomical Union and EuroGeographics, have been active in supporting the preservation of the Struve Arc and advocating its submission for the World Heritage List.

The Struve Geodetic Arc is one of the foremost scientific and technical achievements of its time. The Arc would add to the diversity of the properties on the World Heritage List and has truly universal significance. For almost 200 years, the Struve Geodetic Arc has connected countries from the Black Sea to the Arctic Ocean and will continue to do so in the future.

It is a great honour for me, on behalf of Government of Finland, to extend my sincere thanks to all the organisations and their personnel who have contributed to this project with such zeal. Without this fruitful cooperation it would not have been possible to achieve this documentation and submit it to World Heritage Centre.

Tanja Karpela
Minister of Culture

Acknowledgements

Sincere thanks are expressed to the Director Generals and staff of the National Survey Organisations of the ten Arc countries, and to the Ministry of Culture and National Board of Antiquities of these countries for all their contribution to this Nomination.

The National Survey Organisations, which have been involved in the project and collected the data, selected the points and documented their Arc sites for the Nomination, are

Belarus	The State Committee for Land Resources, Geodesy & Cartography
Estonia	The Estonian Land Board
Finland	The National Land Survey of Finland
Latvia	The State Land Service of Latvia
Lithuania	The National Land Service
Moldova	The State Agency for Land Relations & Cadastre
Norway	The Norwegian Mapping Authority
Russia	The Federal Service of Geodesy & Cartography of Russia
Sweden	The National Land Survey of Sweden
Ukraine	The Main Administration of Geodesy, Cartography & Cadastre

Besides the National Survey Organisations in many countries also Survey Research Institutes or Universities have been involed in the project. Sincere thanks are expressed to their staff.

Sincere thanks are expressed also to the following International Institutions: The International Federation of Surveyors (FIG), The International Association for Geodesy (IAG) and The International Astronomical Union (IAU), for their support of the Nomination in its various phases.

The Struve Geodetic Arc

Summary

The Struve Geodetic Arc is a chain of triangulation survey stretching more or less down the 25° E line of longitude from near Hammerfest in North Norway over 2820 kms south to near Ismail on the Black Sea. This survey was carried out between 1816 and 1855 under the guidance of the astronomer Friedrich George Wilhelm Struve. A scientist whose reputation has been rated in many countries as comparable to that of Isaac Newton. The scheme contained 258 main triangles with 265 main and over 65 subsidiary station points. In today's geography it passes through ten countries viz. Norway, Sweden, Finland, Russian Federation, Estonia, Latvia, Lithuania, Belarus, Republic of Moldova and Ukraine.

The aim of this presentation to the World Heritage Committee is that a selection of 34 of the surviving points spread through the ten countries should be monumented and preserved as a World Heritage Site in recognition of the great contribution the scheme made to the knowledge of the shape and size of the earth. Of equal importance is that the triangulation formed part of the framework for the basic map-making activities in the regions through which it passed.

Overall there are three parts to the project of which part one relates directly to this submission. That is the recovery, verification and monumentation of a selection of the survey stations of the Struve Geodetic Arc. The second part is the indexing and preservation of appropriate Struve Arc documents that are mainly stored in St Petersburg, Moscow and Stockholm so that they will be of assistance to future researchers. The third part is the re-coordination of all the preserved stations by modern Global Navigation Satellite Systems such as GPS, GLONASS and Galileo.

Since starting the project around 1994 all ten countries have indicated a willingness and interest to participate in the project and to select appropriate points within their boundaries. These have now been identified and re-monumented where necessary.

The final selection of points total 34 sites of the Struve Geodetic Arc. They are located in ten countries of the Arc. The number of points in each of the different countries varies from one to six according to the original possible number of points in that country and depending of the survival of points until today. In every country only most the prominent sites have been selected to be taken into the nomination, for example, the Tartu Observatory in Estonia and the Church of Alatornio in Finland. These two are the only buildings which were used for observation and both of them are still in the same form that they had at the time of measurement. Also both terminals, Fuglenaes at the Arctic Ocean and Staro-Nekrassowka near the Black Sea, are included.

The Struve Geodetic Arc would be the first international transboundary serial nomination in the World Heritage List having ten States Parties. It would be also one of the first nominations having a very important role in the history of sciences as a landmark in the history of astronomy, geodesy and mapping. The scientific documentation is an essential part of the Arc and at least as important as its physical sites in the ten countries. To assist understanding of technical aspects of this submission an Appendix I explains the background to the scheme and the terminology involved.

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Belarus
Estonia
Finland
Latvia
Lithuania
Moldova, Republic of
Norway
Russian Federation
Sweden
Ukraine

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Nomination of the

STRUVE GEODETIC ARC

for inscription on the

WORLD HERITAGE LIST

1. Identification of the Property

1. (a)	**Countries of the serial, transboundary nomination:**	**NORWAY** **SWEDEN** **FINLAND** **RUSSIAN FEDERATION** **ESTONIA** **LATVIA** **LITHUANIA** **BELARUS** **REPUBLIC OF MOLDOVA** **UKRAINE**
1. (b)	**State, Province or Region, Municipality**	**Shown in the Serial Nomination Table**
1. (c)	**Name of Property**	**STRUVE GEODETIC ARC**

Serial Nomination Table for the Struve Geodetic Arc

Site No	ORIGINAL NAME Present name	State Party	Province or Region, Municipality	Coordinates of Centre point	Area of Core zone (sq.m)	Area of Buffer zone (sq.m)	Map Annex Nos.
1	**FUGLENAES** Fuglenes	Norway	Finnmark Hammerfest	70° 40' 12" N 23° 39' 48" E	750	1500	1–3
2	**LILLE-REIPAS** Raipas	Norway	Finnmark Alta	69° 56' 19" N 23° 21' 37" E	100	1000	4-7
3	**LOHDIZHJOKKI** Luvdiidcohkka	Norway	Finnmark Kautokeino	69° 39' 52" N 23° 36' 08" E	100	1000	8-10
4	**BÄLJATZ-VAARA** Baelljasvarri	Norway	Finnmark Kautokeino	69° 01' 43" N 23° 18' 19" E	100	1000	11-13
5	**PAJTAS-VAARA** Tynnyrilaki	Sweden	Norrbottens län Kiruna	68º 15' 18" N 22º 58' 59" E	100	1000	14-15
6	**KERROJUPUKKA** Jupukka	Sweden	Norrbottens län Pajala	67º 16' 36" N 23º 14' 35" E	100	1000	16-18
7	**PULLINKI** Pullinki	Sweden	Norrbottens län Övertorneå	66º 38' 47" N 23º 46' 55" E	100	1000	19-21
8	**PERRA-VAARA** Perävaara	Sweden	Norrbottens län Haparanda	66º 01' 05" N 23º 55' 21" E	100	1000	22-24
9	**STUOR-OIVI** Stuorrahanoaivi	Finland	Lapin lääni Enontekiö	68° 40' 57" N 22° 44' 45" E	314	1964	25-26
10	**AVASAKSA** Aavasaksa	Finland	Lapin lääni Ylitornio	66° 23' 52" N 23° 43' 31" E	79	7854	27-28
11	**TORNEA** Alatornion kirkko	Finland	Lapin lääni Tornio	65° 49' 48" N 24° 09' 26" E	1600	19300	29-30
12	**PUOLAKKA** Oravivuori	Finland	Länsi-Suomen lääni Korpilahti	61° 55' 36" N 25° 32' 01" E	79	900	31-32
13	**PORLOM II** Tornikallio	Finland	Etelä-Suomen lääni Lapinjärvi	60° 42' 17" N 26° 00' 12" E	79	1257	33-34
14	**SVARTVIRA** Mustaviiri	Finland	Etelä-Suomen lääni Pyhtää	60° 16' 35" N 26° 36' 12" E	79	5027	35-37
15	**MÄKI-PÄÄLYS** Mäkipällys	Russia	Leningrad Oblast Kingisepp	60° 04' 27" N 26° 58' 11" E	5,5	15400	38-40
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17	**WOIBIFER** Võivere	Estonia	Lääne-Viru Avanduse	59° 03' 28" N 26° 20' 16" E	100	5000	42-44, 46
18	**KATKO** Simuna	Estonia	Lääne-Viru Avanduse	59° 02' 54" N 26° 24' 51" E	100	5000	42-43, 45
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24	**BERESNÄKI** Paliepiukai	Lithuania	Eastern Lithuania Nemėžis	54° 38' 04" N, 25° 25' 45" E	100	1000	60-63
25	**TUPISCHKI** Tupishki	Belarus	Grodno Oblast Oshmyany	54° 17' 30" N 26° 02' 43" E	23	100	64
26	**LOPATI** Lopaty	Belarus	Grodno Oblast Zelva	53° 33' 38" N 24° 52' 11" E	23	100	65
27	**OSSOWNITZA** Ossovnitsa	Belarus	Brest Oblast Ivanovo	52° 17' 22" N 25° 38' 58" E	23	100	66
28	**TCHEKUTSK** Chekutsk	Belarus	Brest Oblast Ivanovo	52° 12' 28" N 25° 33' 23" E	23	100	66
29	**LESKOWITSCHI** Leskovichi	Belarus	Brest Obalst Ivanovo	52° 09' 39" N 25° 34' 17" E	23	100	66
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32	**FELSCHTIN** Felschtin	Ukraine	Khmelnytskiy region Hvardiiske	49° 19' 48" N 26° 40' 55" E	25	100	74-75
33	**BARANOWKA** Baranowka	Ukraine	Khmelnytskiy region Baranivka	49° 08' 55" N 26° 59' 30" E	10	40	76-77
34	**STARO-NEKRASSOWKA** Stara Nekrasivka	Ukraine	Odessa region Nekrasivka	45° 19' 54" N 28° 55' 41" E	25	120	78-80

Note: In Serial Nomination Table above the area of 100 sq m means that a square 10 m by 10 m or a circle with radius of 5,64 m around the point has been designated as the core or buffer zone. Similarly 1000 sq m means a square of 31,62 m by 31,62 m or a circle with radius of 17,84 m has been designated for the buffer zone. The shape and size of all zones has been given or shown on the maps in Appendix II, Maps.

1. (d) Exact location on map and indication of geographical coordinates to the nearest second

All the properties are marked on the corresponding maps listed in Section 1 (e) and included in Appendix II. For coordinates see Serial Nomination Table above.

1. (e) Maps and/or plans showing boundary of area proposed for inscription and of any buffer zone

Maps and plans annexed to the nomination are keyed to the Serial Nomination Table above and listed to the List of Maps below. Maps numbered with capital letters are included to the main part of the Nomination Document and maps numbered from 1 to 70 are annexed to Appendix II of this Document. The small index maps in connection with each site are about in the scale 1:4 million and there are no separate captions or caption list for them.

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Committee for Land Resources, Geodesy and Cartography
under the Council of Ministers of the Republic of Belarus, 2002.

Map 66. OSSOWNITZA (26), TCHEKUTSK (27) and LESKOWITSCHI (28).
Topographic Map, 1:200.000. Map Sheet N-35-XXXII.
Committee for Land Resources, Geodesy and Cartography
under the Council of Ministers of the Republic of Belarus, 2002.

Map 67. RUDY (30).
Topographical Map, 1:100.000. State Agency for Land Relations and Cadastre, 2003.

Map 68. RUDY (30).
Aerial Photography Map, 1:50.000. State Agency for Land Relations and Cadastre, 2003.

Map 69. RUDY (30).
Topographical Map, 1:50.000. State Agency for Land Relations and Cadastre, 2003.

Map 70. RUDY (30).
Topographical Map, 1:25.000. State Agency for Land Relations and Cadastre, 2003.

Map 71. RUDY (30).
Topographical Map, 1:10.000. State Agency for Land Relations and Cadastre, 2003.

Map 72. KATERINOWKA (31).
Location Map, 1:10.000. Main Admistration of Geodesy, Gertography and Cadastre, 2003.

Map 73. KATERINOWKA (31).
Location Map, 1:1.000. Main Admistration of Geodesy, Gertography and Cadastre, 2003.

Map 74. FELSCHTIN (32).
Location Map, 1:10.000. Main Admistration of Geodesy, Gertography and Cadastre, 2003.

Map 75. FELSCHTIN (32).
Location Map, :1.000. Main Admistration of Geodesy, Gertography and Cadastre, 2003.

Map 76. BARANOWKA (33).
Location Map, 1:10.000. Main Admistration of Geodesy, Gertography and Cadastre, 2003.

Map 77. BARANOWKA (33).
Location Map, 1:1.000 Main Admistration of Geodesy, Gertography and Cadastre, 2003.

Map 78. STARO-NEKRASSOWKA (34).
Topographic Map, 1:200.000, Odessa region. Kyiv Military-Cartographic Factory, 2000.

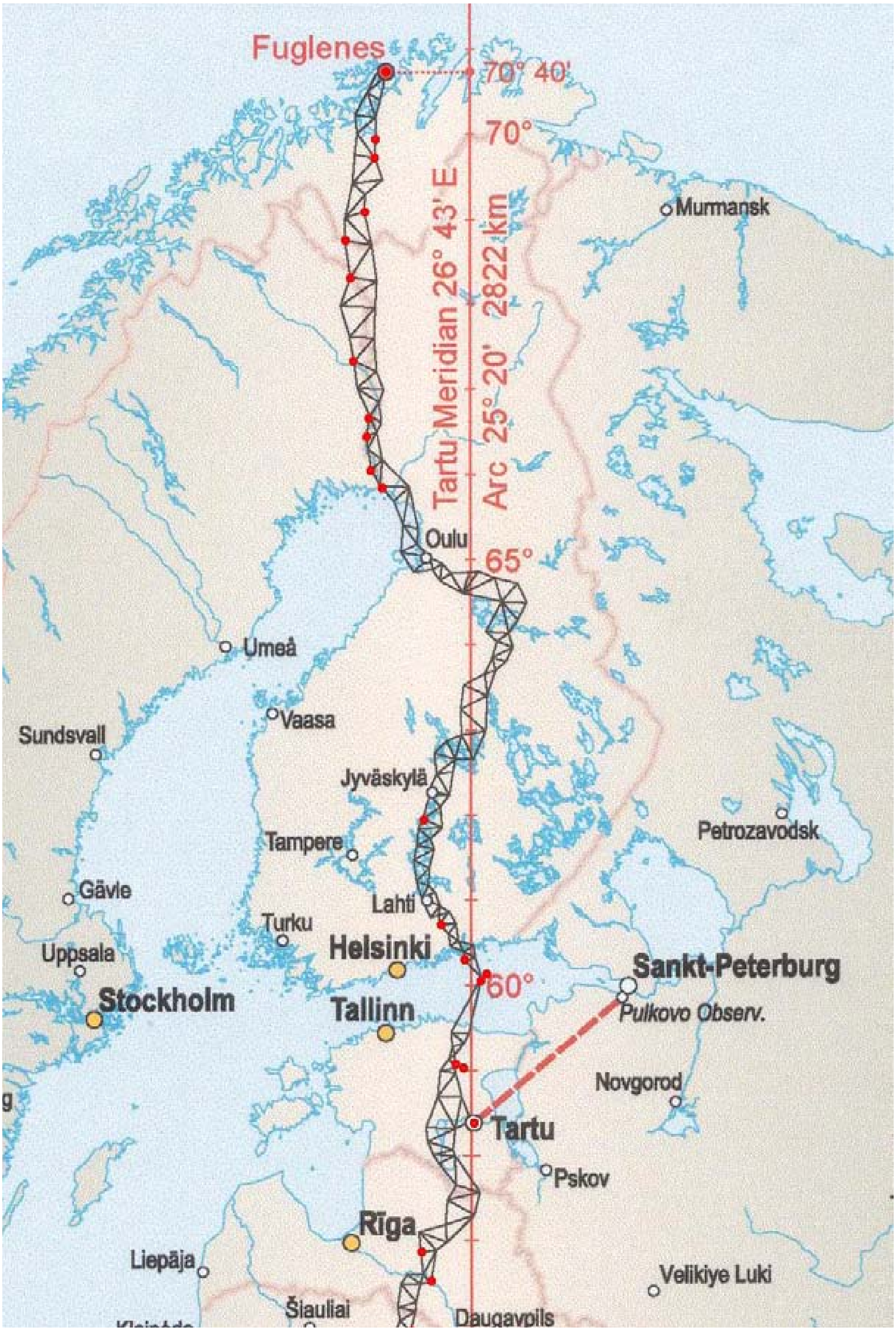
Map 79. STARO-NEKRASSOWKA (34). Main Admistration of Geodesy, Gertography and Cadastre, 2003.
Location Map, 1:10.000.

Map 80. STARO-NEKRASSOWKA (34). Main Admistration of Geodesy, Gertography and Cadastre, 2003.
Location Map, 1:1.000.

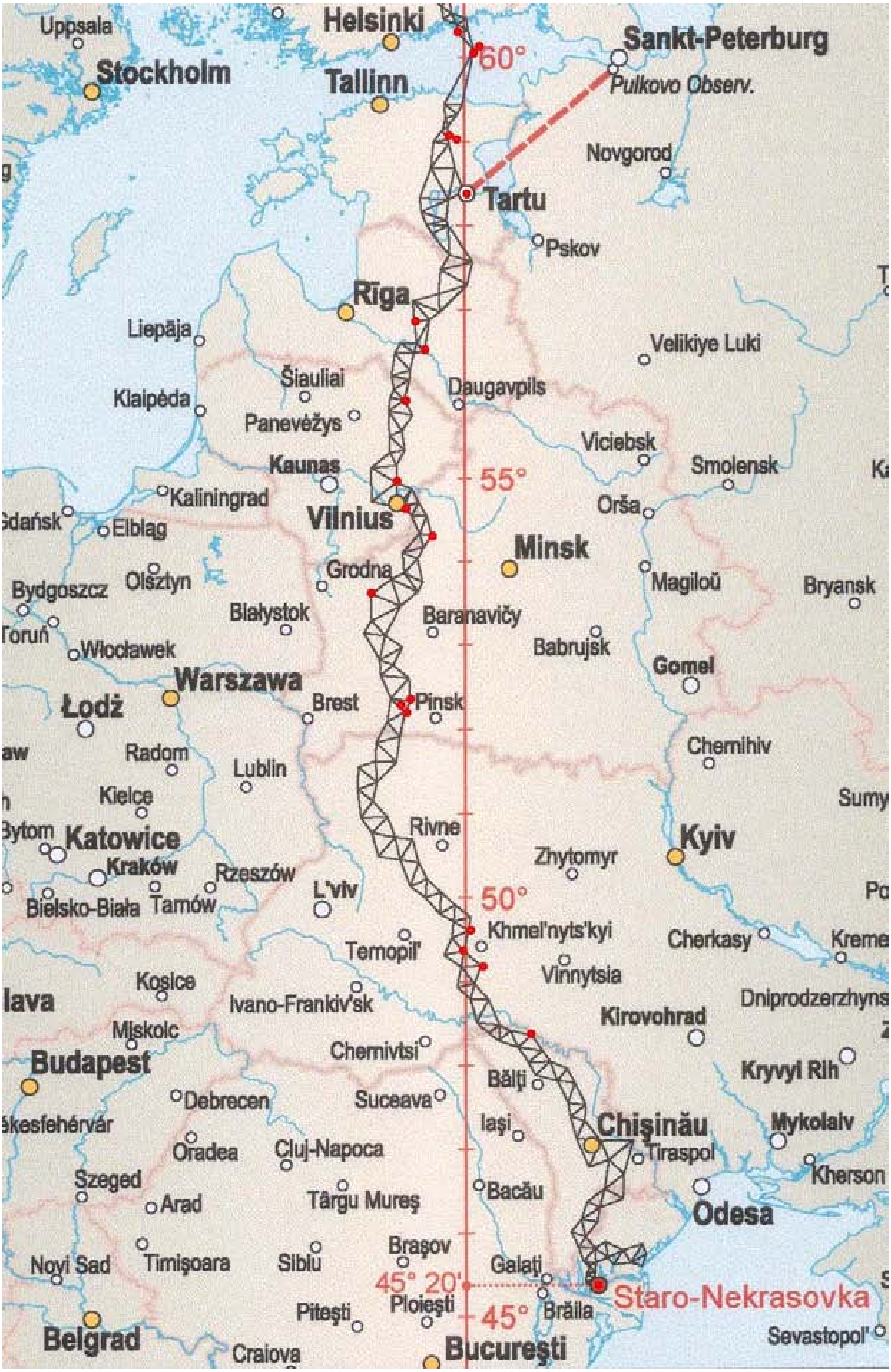
1. (f) Area of property proposed for inscription and proposed buffer zone

See Serial Nomination Table above.

Map A.
Map of the Struve Geodetic Arc between Fuglenaes (Norway) and Staro-Nekrassowka (Ukraine), Scale 1:13 million.



Map B. Part 1 (2).
Map of the Struve Geodetic Arc with the sites selected to the Nomination. Scale about 1:6 million.


Helsinki
Sankt-Peterburg
Pulkovo Observ.
Uppsala
Stockholm
Tallinn
60°
Novgorod
Tartu
Pskov
Riga
Liepāja
Velikiye Luki
Šiauliai
Daugavpils
Klaipėda
Panevėžys
Viciebsk
Kaunas
Smolensk
55°
Kaliningrad
Orša
Vilnius
Gdańsk
Elbląg
Minsk
Grodna
Magiloŭ
Bryansk
Bydgoszcz
Olsztyn
Białystok
Baranavičy
Toruń
Włocławek
Babrujsk
Gomel
Warszawa
Brest
Pinsk
Łodż
Radom
Chernihiv
Lublin
Kielce
Sumy
Bytom
Katowice
Rivne
Kyiv
Kraków
Zhytomyr
Rzeszów
L'viv
50°
Bielsko-Biała
Tarnów
Khmel'nyts'kyi
Ternopil'
Cherkasy
Vinnytsia
Kosice
Ivano-Frankiv'sk
Dniprodzerzhyns
Kirovohrad
Miskolc
Chernivtsi
Budapest
Kryvyi Rih
Bălţi
Debrecen
Suceava
Iaşi
Chişinău
Mykolaiv
Oradea
Cluj-Napoca
Tiraspol
Kherson
Szeged
Târgu Mureş
Bacău
Arad
Odesa
Braşov
Novi Sad
Timişoara
Sibiu
Galaţi
45° 20'
Staro-Nekrasovka
Piteşti
Ploieşti
45°
Brăila
Belgrad
Craiova
Bucureşti
Sevastopol'

Map B. Part 2 (2)

Map C.

"Carte Generale des Triangles de l´Arc du Meridien" from Struve F.G.W. *Arc du méridien de 25º 20′ entre le Danube et la Mer Glaciale mésure depuis 1816 jusqu'en 1855.* Planches. St Petersburg, 1860. The 34 properties selected for of Nomination and their site numbers are marked on the maps. (Totally 11 map pages).

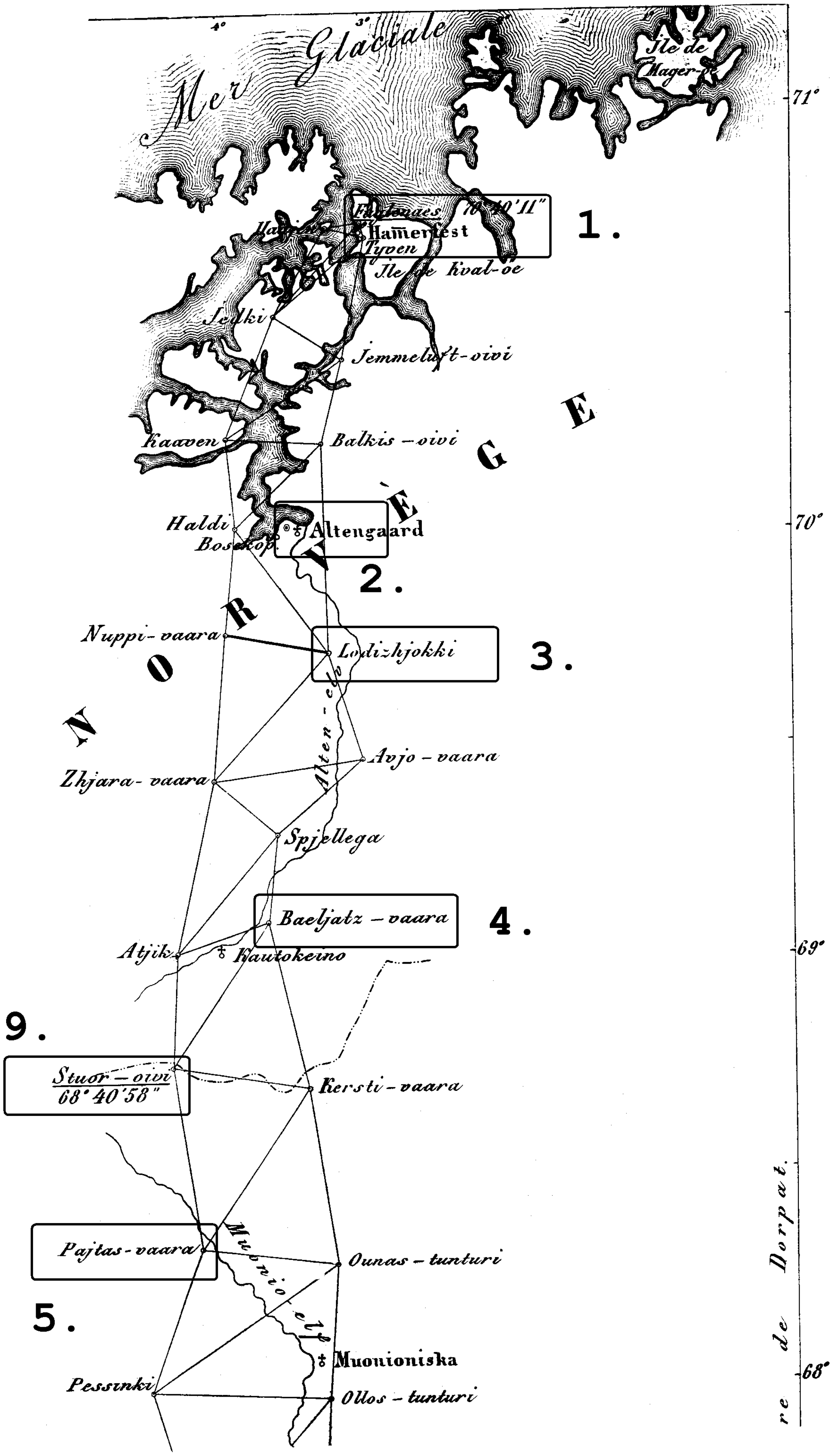
CARTE GÈNÈRALE

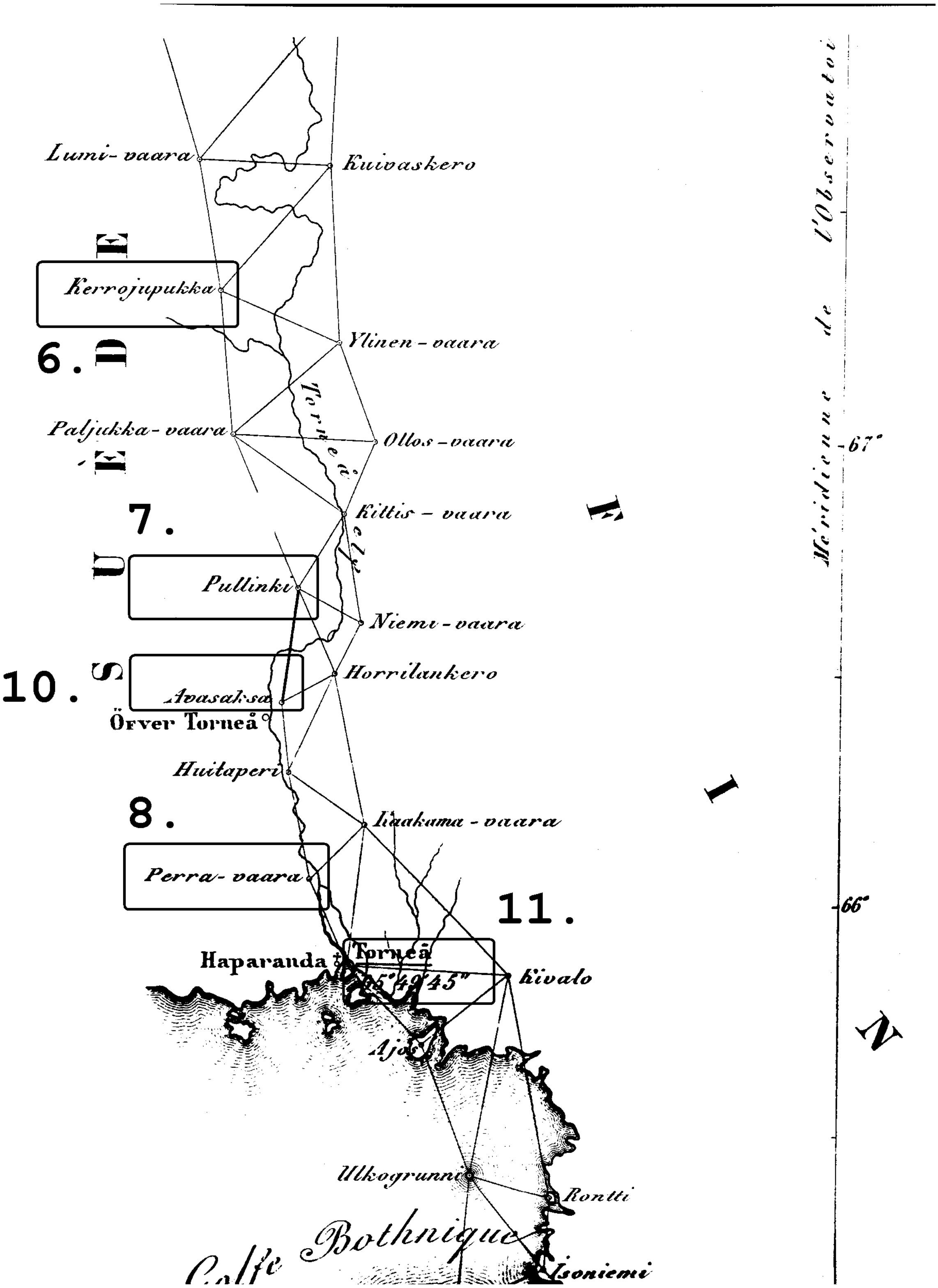
DES TRIANGLES DE L'ARC DU MÈRIDIEN

mesuré entre

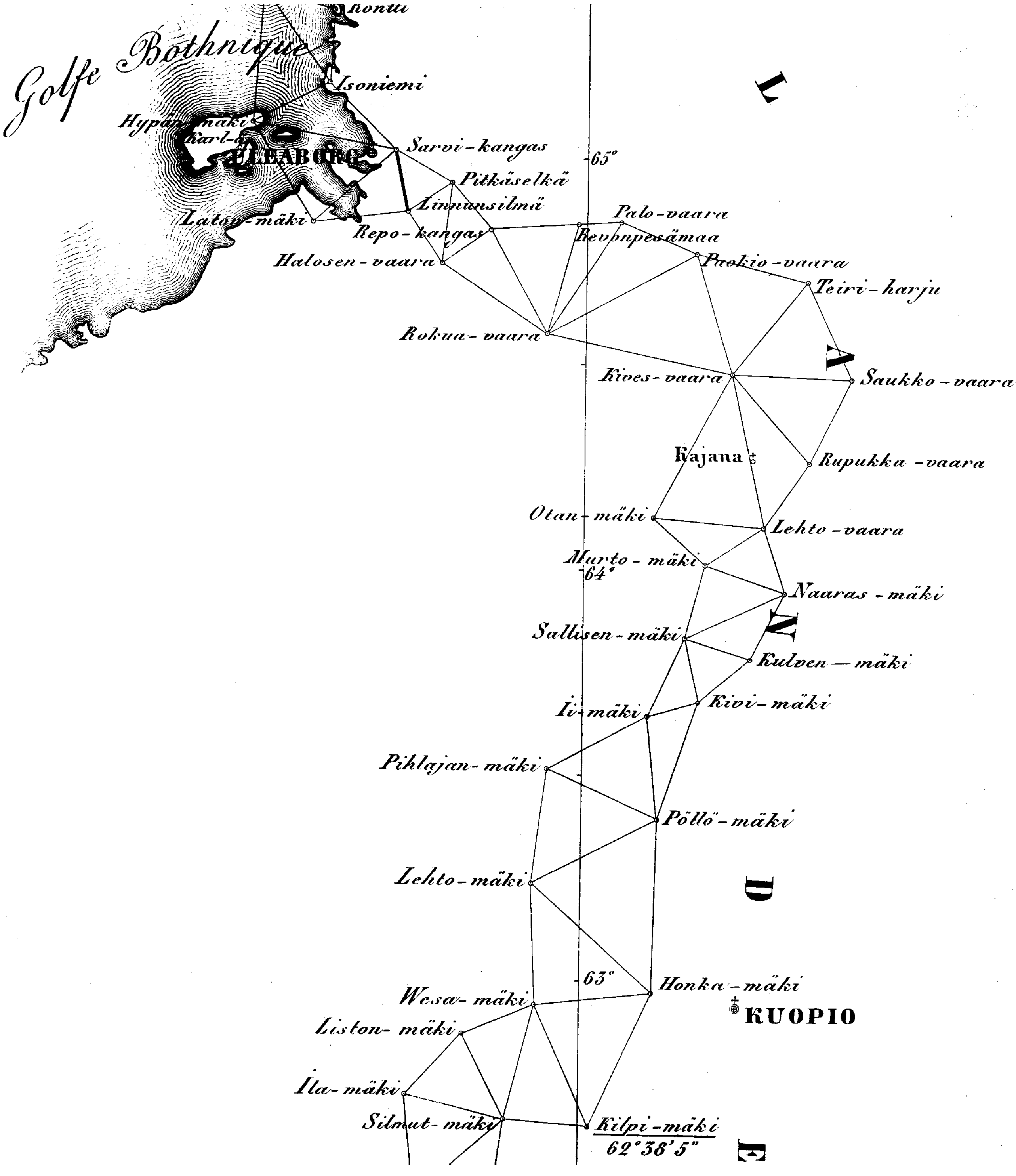
LE DANUBE ET LA MER GLACIALE

depuis 1816 jusqu'en 1855.

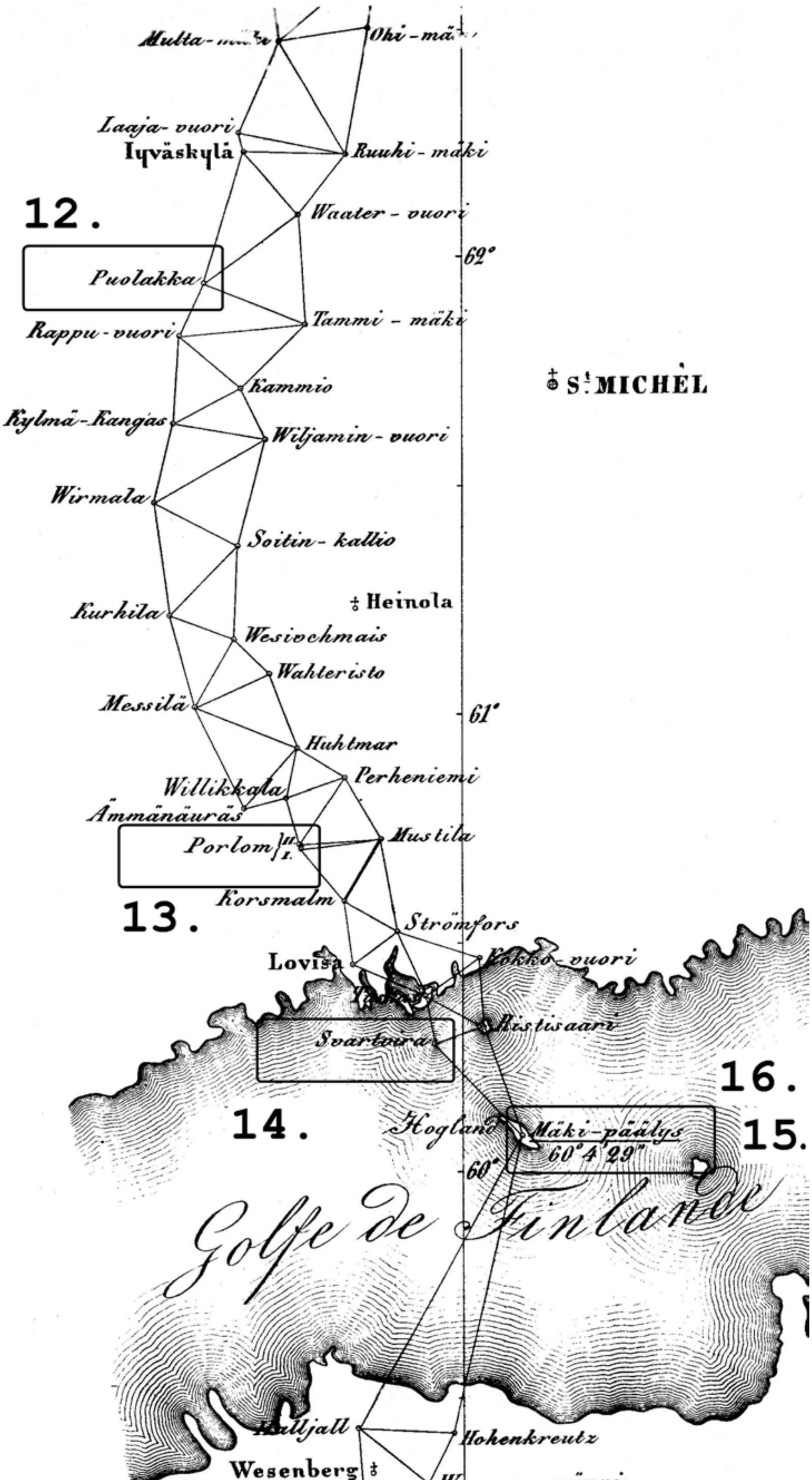

Mer Glaciale
Ile de Mager-öe
71°
Fuglenaes 70°40'11"
Hammerfest
Tyven
Ile de Kval-öe
1.
Jedki
Jemmeluft-oivi
Kaaven
Balkis-oivi
NORVÈGE
Haldi
Bosekop
Altengaard
2.
70°
Nuppi-vaara
Lodizhjokki
3.
Alten-elf
Avjo-vaara
Zhjara-vaara
Spjellega
Baeljatz-vaara
4.
Atjik
Kautokeino
69°
9.
Stuor-oivi
68°40'58"
Kersti-vaara
Pajtas-vaara
Muonio elf
Ounas-tunturi
5.
Muonioniska
Pessinki
Ollos-tunturi
68°
re de Dorpat.

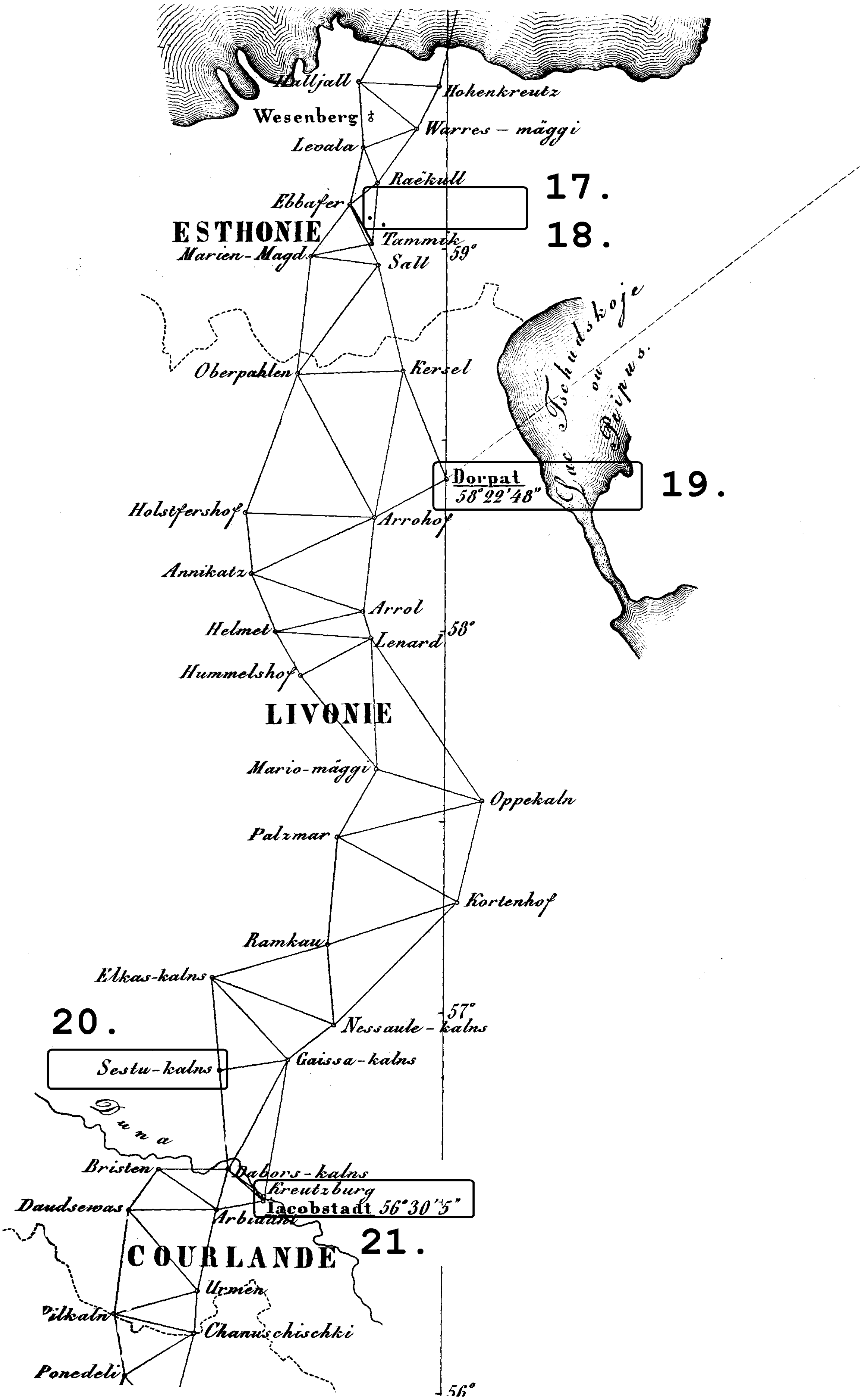


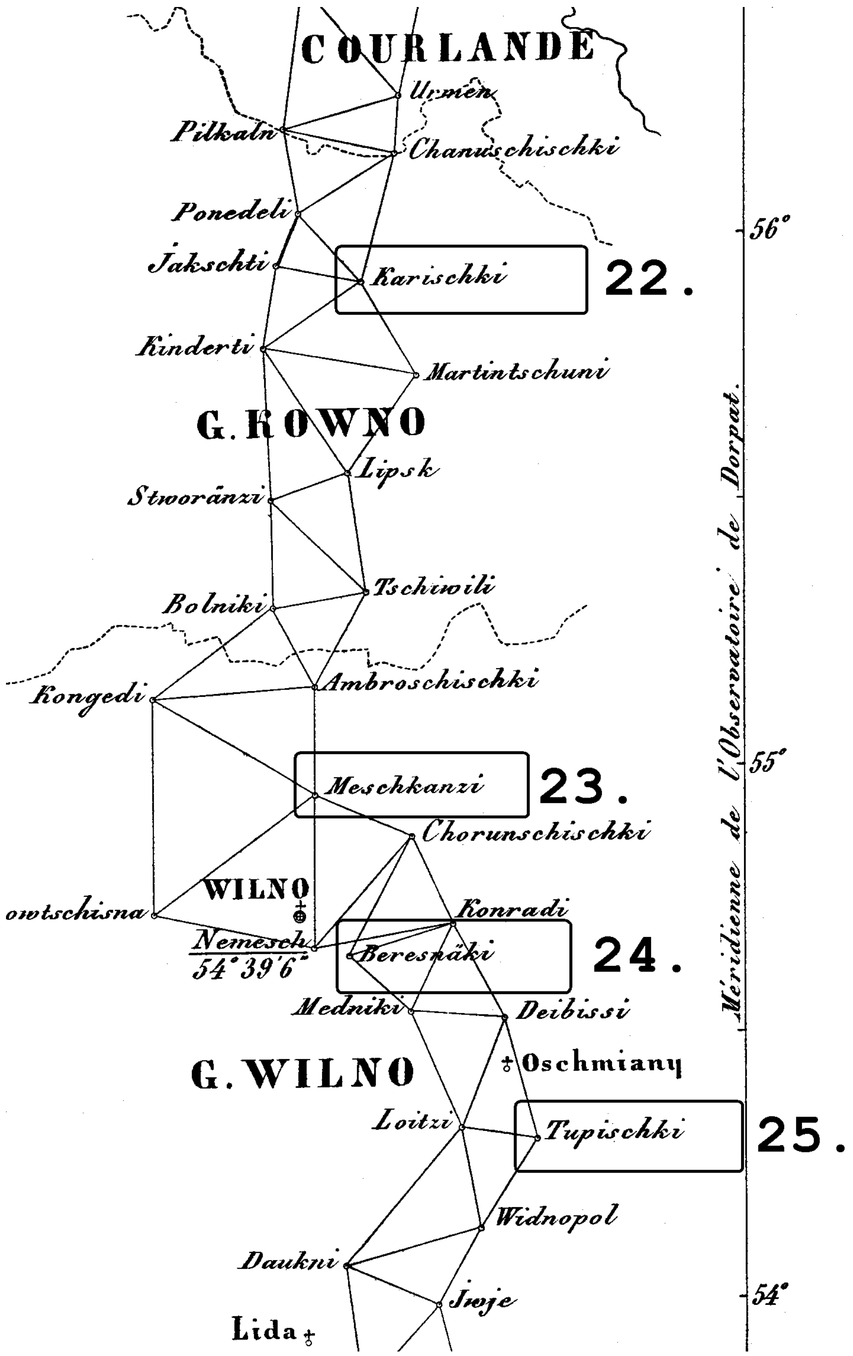
Lumi- vaara
Kuivaskero
Kerrojupukka
6.
Ylinen - vaara
Paljukka - vaara
Ollos - vaara
Torne å elf
Kittis - vaara
7.
Pullinki
Niemi - vaara
10.
Horrilankero
Avasaksa
Örver Torneå
Huitaperi
8.
Kaakama - vaara
Perra- vaara
11.
Haparanda
Torneå
Kivalo
Ajos
Ulkogrunni
Rontti
Golfe Bothnique
Isoniemi
Méridienne de l'Observatoi
67°
66°

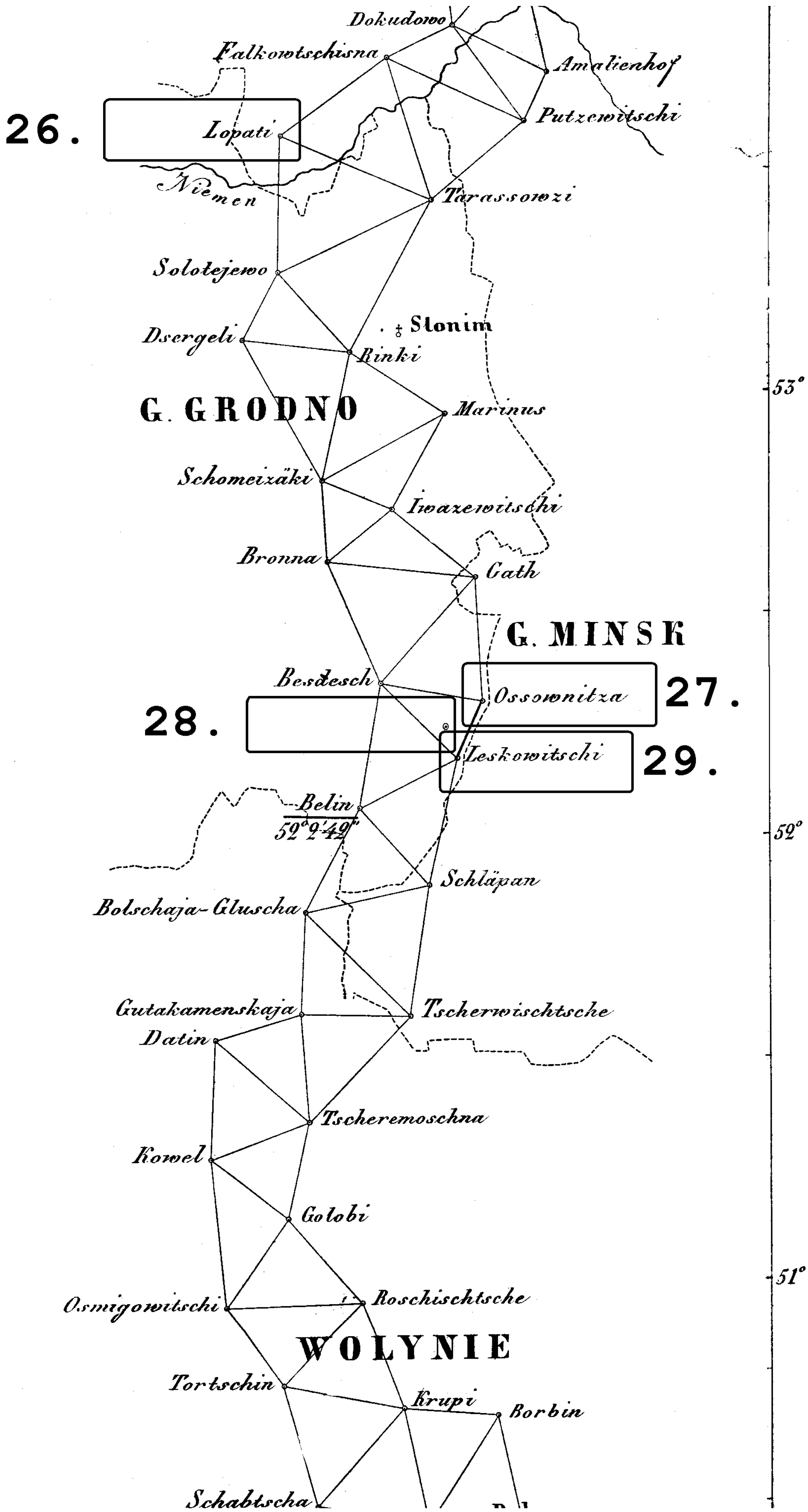


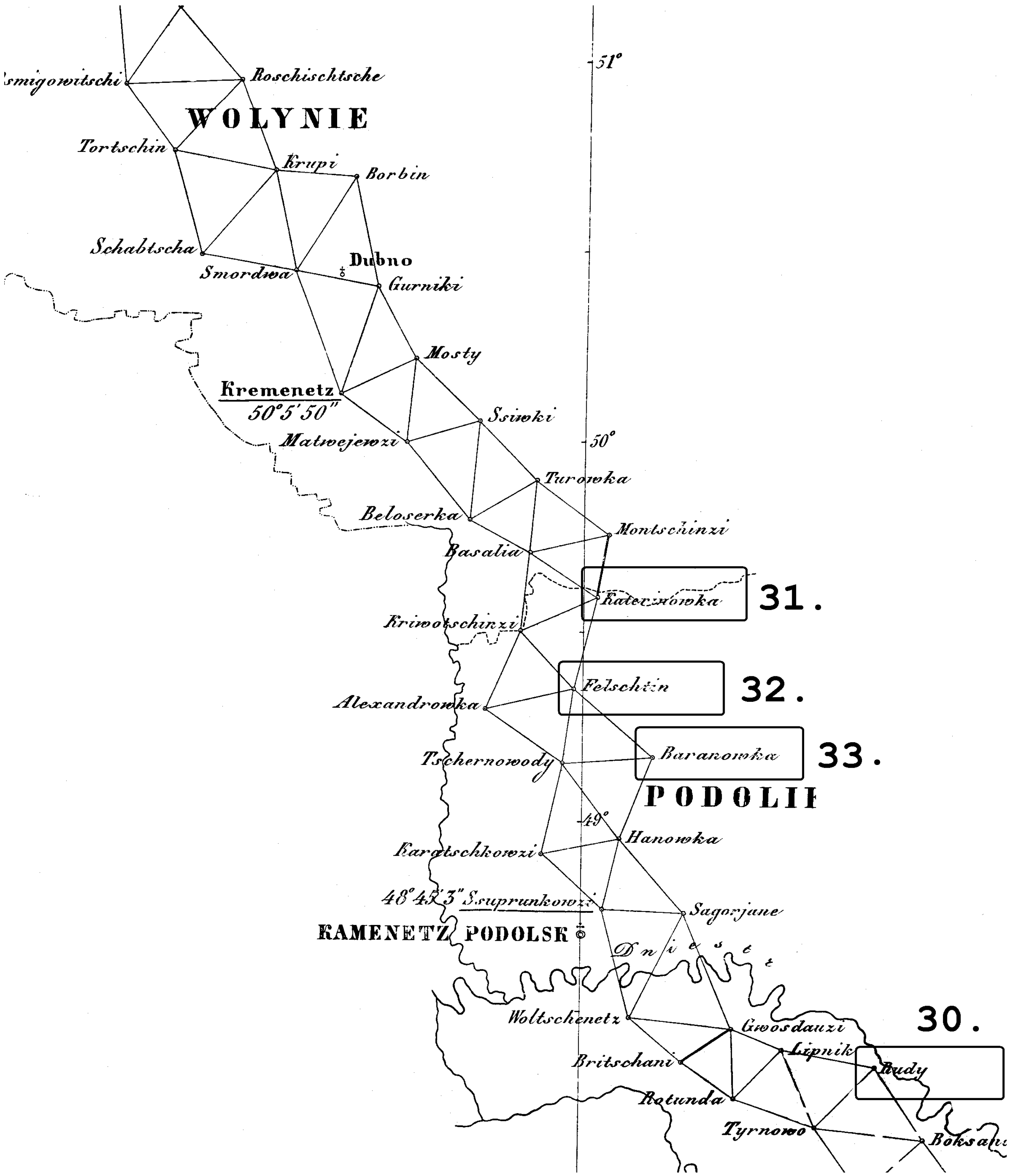
Golfe Bothnique
Kontti
Isoniemi
Hypän-mäki
ULEABORG
Sarvi-kangas
-65°
Pitkäselkä
Linnunsilmä
Palo-vaara
Repo-kangas
Revonpesämaa
Halosen-vaara
Paakio-vaara
Teiri-harju
Rokua-vaara
Kives-vaara
Saukko-vaara
Kajana
Rupukka-vaara
Otan-mäki
Lehto-vaara
Murto-mäki
64°
Naaras-mäki
Sallisen-mäki
Kulven-mäki
Ii-mäki
Kivi-mäki
Pihlajan-mäki
Pöllö-mäki
Lehto-mäki
D
63°
Honka-mäki
Wesa-mäki
KUOPIO
Liston-mäki
Ila-mäki
Silmut-mäki
Kilpi-mäki
62°38'5"


Multa-mäki
Ohi-mäki
Laaja-vuori
Jyväskylä
Ruuhi-mäki
12.
Waater-vuori
62°
Puolakka
Tammi-mäki
Rappu-vuori
St MICHEL
Kammio
Kylmä-Kangas
Wiljamin-vuori
Wirmala
Soitin-kallio
Heinola
Kurhila
Wesivehmais
Wahteristo
Messilä
61°
Huhtmar
Perheniemi
Willikkala
Ämmänäuräs
Porlom II. I.
Mustila
Korsmalm
13.
Strömfors
Lovisa
Kokko-vuori
Svartvira
Ristisaari
16.
14.
Hogland
Mäki-päälys 60° 4' 29"
15.
60°
Golfe de Finlande
Hohenkreutz
Wesenberg
Warres-mäggi
Levala

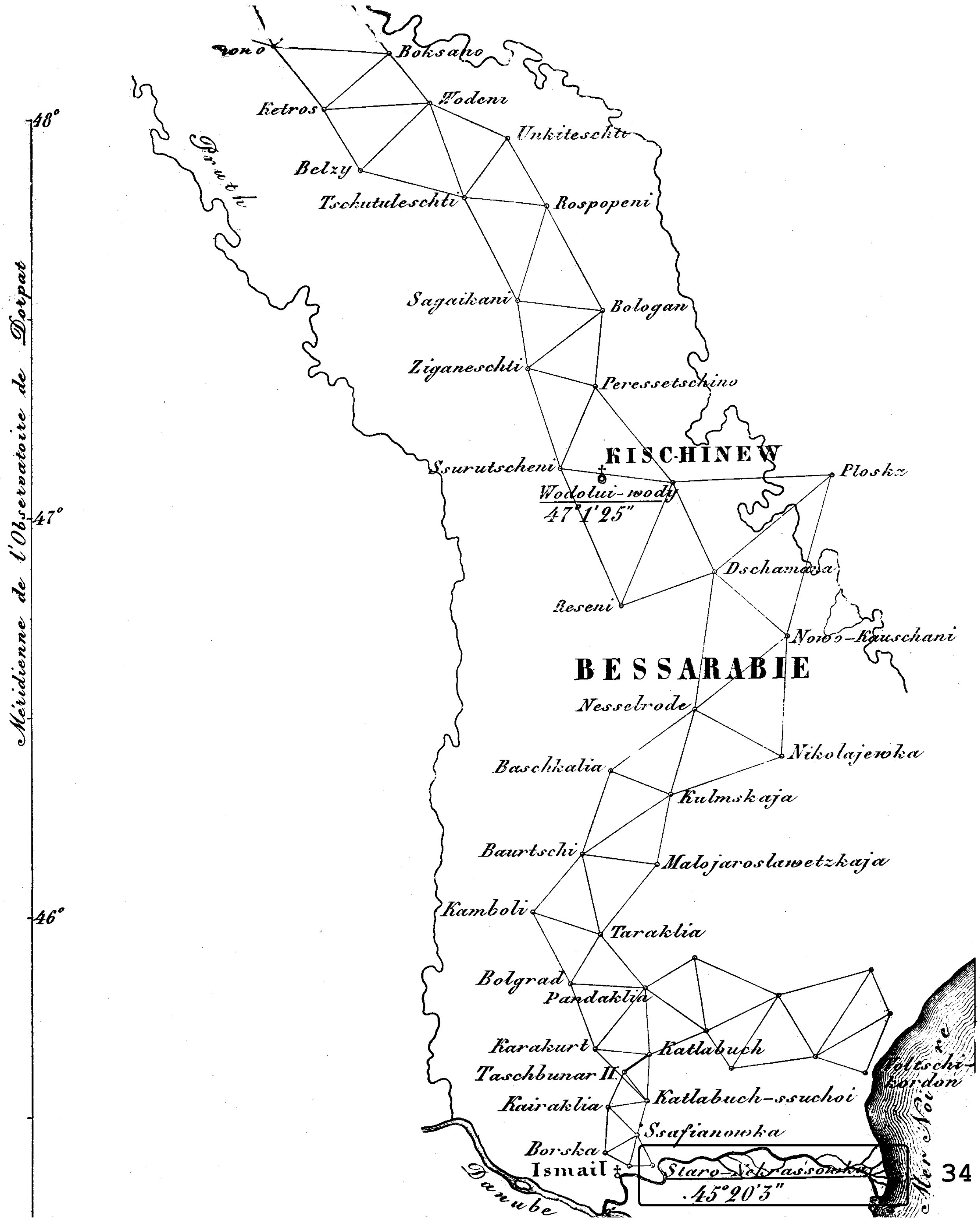

Halljall
Hohenkreutz
Wesenberg
Warres – mäggi
Levala
Raëkull
17.
Ebbafer
18.
ESTHONIE
Tammik
Marien-Magd.
Sall
59°
Lac Tschudskoje ou Peipus.
Oberpahlen
Kersel
Dorpat
58°22'48"
19.
Holstfershof
Arrohof
Annikatz
Arrol
Helmet
Lenard
58°
Hummelshof
LIVONIE
Mario-mäggi
Oppekaln
Palzmar
Kortenhof
Ramkau
Elkas-kalns
20.
57°
Nessaule – kalns
Sestu-kalns
Gaissa-kalns
Duna
Bristen
Dabors-kalns
Kreutzburg
Daudsewas
Jacobstadt 56°30'5"
Arbiauni
21.
COURLANDE
Urmen
Pilkaln
Chanuschischki
Ponedeli
56°


COURLANDE
Urmen
Pilkaln
Chanuschischki
Ponedeli
56°
Jakschti
Karischki
22.
Kinderti
Martintschuni
G. KOWNO
Lipsk
Stworänzi
Tschiwili
Bolniki
Kongedi
Ambroschischki
Méridienne de l'Observatoire de Dorpat.
55°
Meschkanzi
23.
Chorunschischki
WILNO
owtschisna
Konradi
Nemesch
54° 39′ 6″
Berespäki
24.
Medniki
Deibissi
Oschmiany
G. WILNO
Loitzi
Tupischki
25.
Widnopol
Daukni
Jwje
54°
Lida

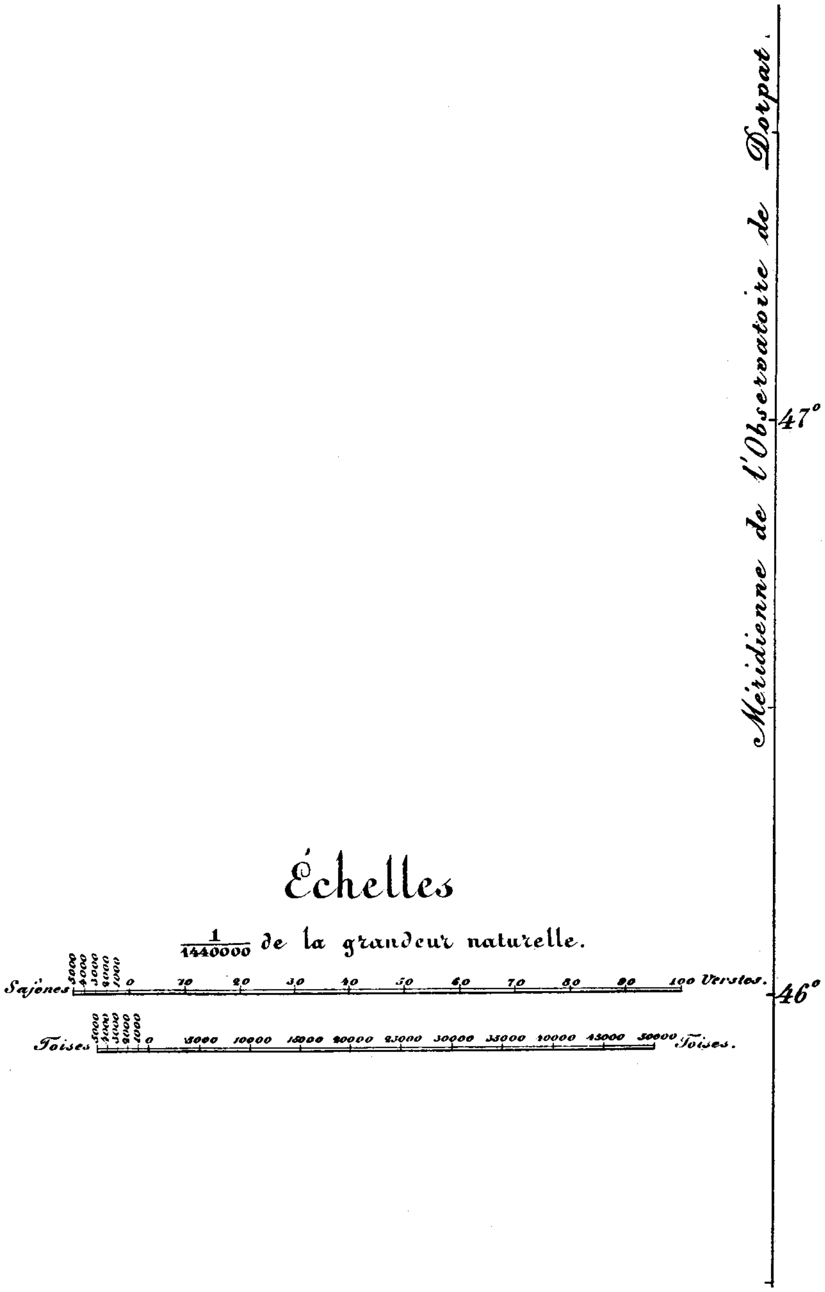

26.
27.
28.
29.
Dokudowo
Falkowtschisna
Amalienhof
Putzewitschi
Lopati
Niemen
Tarassowzi
Solotejewo
Stonim
Dsergeli
Rinki
G. GRODNO
Marinus
53°
Schomeizäki
Iwazewitschi
Bronna
Gath
G. MINSK
Besdesch
Ossowitza
Leskowitschi
Belin
52°2'42"
52°
Schläpan
Bolschaja-Gluscha
Gutakamenskaja
Tscherwischtsche
Datin
Tscheremoschna
Kowel
Golobi
51°
Osmigowitschi
Roschischtsche
WOLYNIE
Tortschin
Krupi
Borbin
Schabtscha



WOLYNIE
Smigowitschi
Roschischtsche
Tortschin
Krupi
Borbin
Schabtscha
Smordwa
Dubno
Gurniki
Mosty
Kremenetz
50°5'50"
Ssiwki
Matwejewzi
Turowka
Beloserka
Montschinzi
Basalia
Katerinowka
31.
Kriwotschinzi
Felschtin
32.
Alexandrowka
Tschernowody
Baranowka
33.
PODOLIE
Hanowka
Karatschkowzi
48°45'3" Ssuprunkowzi
Sagorjane
KAMENETZ PODOLSK
Dniester
Woltschenetz
Gwosdauzi
30.
Lipnik
Britschani
Rudy
Rotunda
Tyrnowo
Boksanı
51°
50°
49°


Méridienne de l'Observatoire de Dorpat
48°
47°
46°
Pruth
Boksaho
Ketros
Wodeni
Unkiteschti
Belzy
Tschutuleschti
Rospopeni
Sagaikani
Bologan
Ziganeschti
Peressetschino
KISCHINEW
Ssurutscheni
Wodolui-wody
47°1'25"
Ploska
Dschamana
Reseni
Nowo-Kauschani
BESSARABIE
Nesselrode
Nikolajewka
Baschkalia
Kulmskaja
Baurtschi
Malojaroslawetzkaja
Kamboli
Taraklia
Bolgrad
Pandaklia
Karakurt
Katlabuch
Taschbunar II.
Kairaklia
Katlabuch-ssuchoi
Ssafianowka
Borska
Ismail
Staro-Nekrassowka
45°20'3"
Danube
Woleschi-kordon
Mer Noire

34.


Méridienne de l'Observatoire de Dorpat.
47°
46°
Échelles
1/1440000 de la grandeur naturelle.
Sajènes 5000 4000 3000 2000 1000 0 10 20 30 40 50 60 70 80 90 100 Verstes.
Toises 5000 4000 3000 2000 1000 0 5000 10000 15000 20000 25000 30000 35000 40000 45000 50000 Toises.

Coordinates of points on the Struve Geodetic Arc

Legend for the columns of the Coordinate Table below.

a. **No**. is a running number from north to south
b. **Tri. No.** is the triangle number used by Struve on his triangulation diagrams.
c. **Struve No.** is that used by Struve in his volumes.
d. **Struve name** is as the spellings on Struve's triangulation diagrams.
e. **Alternative name(s)** is a modern name or old variant (marked with “ “).
f. **Lat N** is latitude in the format: N / North; DDºMM'SS”, where, DDº = Degrees, MM' = Minutes, SS” = Seconds.
g. **Long E** is longitude in the format: E / East; DDºMM'SS”
h. **State party** i.e. Country
i. **Site No**. designates those points proposed for the World Heritage List, see Serial Nomination Table in chapter 1. (b).

Notes for the Coordinate Table information

1. Points selected for preservation with “Site no” in the column (i).
2. Stations in **bold** = astronomical stations. On these points the determination of longitudes, latitudes and azimuths were made by observation of the directions of stars.
3. The latitudes and longitudes are given on the GRS80 ellipsoid* as they are computed in 2003 in National Land Survey of Finland using observations documented in Struve´s *Arc du méridien de 25º 20' entre le Danube et la Mer Glaciale mésure depuis 1816 jusqu'en 1855*.
(* ”GRS80 ellipsoid” is a geocentric reference ellipsoid adopted 1979 and a geodetic datum, in that it defines the centre of mass of the earth as its origin, and the direction of the earth's axis as the minor axis of the reference ellipsoid.)
4. The list includes the main points but not the end points of the baselines and other special points.
5. Note that five of the points recommended for inclusion are subsidiary points used by Struve and are not included in the table below. These points are:

2 LILLE-REIPAS, Alta baseline extension point E
16 HOGLAND, Point Z, astronomical point
17 WOIBIFER, Simonis base NW terminal
18 KATKO, Simonis base SE terminal
28 TCHEKUTSK, Ossownitza base NE terminal

Table 1. **Coordinates of points on the Arc**

No.	Tri. No.	Struve No.	Struve name	Alternative name(s)	Lat N	Long E	State party	Site no
a	b	c	d	e	f	g	h	i
1	258	XII 15	**Fuglenaes**	Fuglenes-Hammerfest	70 40 12	23 39 48	Norway	**1**
2	-	-	Haajen (Ext. stn)	Håja	70 39 18	23 25 42	Norway	
3	257	XII 14	Tyven	Tjuven	70 38 23	23 41 54	Norway	
4	256	XII 13	Jedki	Seilandstuva	70 26 46	23 05 42	Norway	
5	255	XII 12	Jemmeluft-oivi	Gosviktind	70 21 00	23 35 52	Norway	
6	254	XII 11	Kaaven	Koven	70 08 57	22 49 45	Norway	
7	253	XII 10	Balkis-oivi	Vardfjellet	70 09 04	23 28 49	Norway	
8	252	XII 9	Haldi	Sukkertoppen	69 56 22	22 55 22	Norway	
9	251	XII 8	Nuppi-vaara	Nuppealas	69 41 41	22 53 46	Norway	
10	250	XII 7	Lohdizhjokki	Luvdiidcohkka, Lodiken	69 39 52	23 36 08	Norway	**3**
11	249	XII 6	Avjo-vaara	Avjuvarri	69 25 14	23 51 48	Norway	
12	248	XII 5	Zhjara-vaara	Caravarri	69 21 09	22 53 10	Norway	
13	247	XII 4	Spjellega	Spielgavarri	69 13 52	23 20 06	Norway	
14	247	XII 3	Bäljatz-vaara	Baelljasvarri	69 01 43	23 18 19	Norway	**4**
15	247	XII 2	Atjik	Addjit	68 56 24	22 44 35	Norway	
16	245	XII1/XI21	**Stuor-oivi**	Stuorrahanoaivi	68 40 57	22 44 45	Finland	**9**
17	243	XI 20	Kersti-vaara	”Kerstivara” Jerstivaara	68 38 58	23 42 43	Finland	
18	242	XI 19	Pajtas-vaara	Tynnyrilaki	68 15 18	22 58 59	Sweden	**5**
19	241	XI 18	Ounas-tunturi	”Aunastunturi” Ounastunturi	68 14 02	23 49 39	Finland	
20	240	XI 17	Pessinki		67 54 44	22 43 12	Sweden	
21	239	XI 16	Ollos-tunturi	”Ollostunturi” Olostunturi	67 55 27	23 48 30	Finland	
22	238	XI 15	Lumi-vaara	Lumivara	67 33 04	23 04 07	Sweden	
23	237	XI 14	Kuivaskero	Kiuaskero	67 33 21	23 48 36	Finland	

24	236	XI 13	Kerrojupukka	Jupukka	67 16 36	23 14 35	Sweden	**6**
25	235	XI 12	Ylinen-vaara	”Ilinenvaara” Ylinenvaara	67 10 37	23 55 07	Finland	
26	234	XI 11	Ollos-vaara	”Ollosvara” Olosvaara	66 58 09	24 08 27	Finland	
27	233	XI 10	Paljukka-vaara	Paljukkavaara	66 58 08	23 21 49	Sweden	
28	232	XI 9	Kittis-vaara	”Kittis” Kittisvaara	66 48 36	24 00 32	Finland	
29	231	XI 8	Niemi-vaara	Niemivaara	66 34 40	24 07 35	Finland	
30	230	XI 7	Pullinki		66 38 47	23 46 55	Sweden	**7**
31	229	XI 6	Avasaksa	Aavasaksa	66 23 52	23 43 31	Finland	**10**
32	228	XI 5	Horrilankero	”Gorrilankero”	66 27 54	24 00 15	Finland	
33	228	XI 4	Huitaperi	”Guitaperi”	66 14 54	23 46 58	Finland	
34	226	XI 3	Perra-vaara		66 01 05	23 55 21	Sweden	**8**
35	225	XI 2	Kaakama-vaara	Tynnyrilaki	66 08 27	24 11 52	Finland	
36	226	XI1/X35	**Tornea**	Tornio	65 49 48	24 09 26	Finland	**11**
37	223	X 34	Ajos		65 40 03	24 33 12	Finland	
38	222	X 33	Kivalo		65 49 23	25 00 25	Finland	
39	221	X 32	Rontti		65 20 43	25 14 44	Finland	
40	220	X 31	Ulkogrunni	Ulkokrunni	65 23 21	24 50 20	Finland	
41	219	X 30	Isoniemi		65 09 45	25 14 12	Finland	
42	218	X 29	Hyypän-mäki		65 03 50	24 48 02	Finland	
43	217	X 28	Laton-mäki		64 49 37	25 09 33	Finland	
44	216	X 27	Sarvi-kangas		65 00 27	25 37 15	Finland	
45	215	X 26	Linnunsilmä		64 51 12	25 41 42	Finland	
46	214	X 25	Pilkäselkä		64 55 37	25 55 52	Finland	
47	213	X 24	Halosen-vaara		64 43 32	25 53 35	Finland	
48	212	X 23	Repo-kangas		64 48 32	26 09 37	Finland	
49	211	X 22	Revonpesämaa		64 49 29	26 40 13	Finland	
50	210	X 21	Palo-vaara		64 49 38	26 55 00	Finland	
51	209	X 20	Rokua-vaara		64 33 52	26 29 41	Finland	
52	208	X 19	Puokio-vaara		64 44 52	27 20 33	Finland	
53	207	X 18	Teiri-harju		64 40 41	27 57 56	Finland	
54	206	X 17	Saukko-vaara		64 26 53	28 12 28	Finland	
55	205	X 16	Rupukka-vaara		64 14 33	27 57 39	Finland	
56	204	X 15	Kives-vaara		64 27 37	27 32 28	Finland	
57	203	X 14	Otan-mäki		64 07 05	27 06 07	Finland	
58	202	X 13	Lehto-vaara		64 05 08	27 42 30	Finland	
59	201	X 12	Murto-mäki		63 59 55	27 23 49	Finland	
60	200	X 11	Naaras-mäki		63 55 48	27 49 34	Finland	
61	199	X 10	Kulven-mäki		63 46 05	27 38 30	Finland	
62	198	X 9	Sallisen-mäki		63 49 20	27 16 58	Finland	
63	197	X 8	Kivi-mäki		63 39 55	27 21 02	Finland	
64	196	X 7	Ii-mäki		63 37 46	27 04 31	Finland	
65	195	X 6	Pihlajan-mäki		63 30 13	26 24 06	Finland	
66	194	X 5	Pöllö-mäki		63 22 47	27 07 45	Finland	
67	193	X 4	Lehto-mäki		63 13 50	26 27 02	Finland	
68	194	X 3	Honka-mäki		62 57 28	27 06 23	Finland	
69	193	X2/IX37	Wesa-mäki		62 55 45	26 28 50	Finland	
70	191	X1/IX38	**Kilpi-mäki**		62 38 03	26 46 04	Finland	
71	189	IX 36	Liston-mäki		62 51 30	26 05 51	Finland	
72	188	IX 35	Ila-mäki		62 42 37	25 47 56	Finland	
73	187	IX 34	Silmut-mäki		62 39 03	26 19 02	Finland	
74	186	IX 33	Ohi-mäki		62 29 33	26 16 27	Finland	
75	185	IX 32	Multa-mäki		62 27 45	25 51 45	Finland	
76	184	IX 31	Laaja-vuori		62 15 29	25 41 03	Finland	
77	183	IX 30	Ruuhi-mäki		62 12 49	26 11 04	Finland	
78	182	IX 29	Jyvaskylä		62 12 48	25 42 03	Finland	
79	181	IX 28	Waater-vuori		62 04 29	25 57 40	Finland	
80	180	IX 27	Puolakka	Oravivuori	61 55 36	25 32 01	Finland	**12**
81	179	IX 26	Tammi-mäki		61 50 06	25 59 46	Finland	
82	178	IX 25	Rappu-vuori		61 48 37	25 25 40	Finland	
83	177	IX 24	Kammio		61 41 51	25 42 11	Finland	
84	176	IX 23	Kylmä-kangas		61 37 32	25 24 39	Finland	
85	175	IX 22	Wiljamin-vuori		61 35 21	25 49 29	Finland	
86	174	IX 21	Wirmala		61 26 60	25 19 20	Finland	
87	173	IX 20	Soitin-kallio		61 21 35	25 42 26	Finland	

88	172	IX 19	Kurhila		61 12 18	25 24 07	Finland	
89	171	IX 18	Wesivehmais		61 09 21	25 41 25	Finland	
90	170	IX 17	Wahteristo		61 04 48	25 51 28	Finland	
91	169	IX 16	Messilä		61 00 25	25 31 31	Finland	
92	168	IX 15	Ämmänäuräs		60 47 16	25 45 04	Finland	
93	167	IX 14	Huhtmar		60 55 04	25 58 56	Finland	
94	166	IX 13	Willikkala		60 48 33	25 56 41	Finland	
95	165	IX 12	Perheniemi		60 51 01	26 11 26	Finland	
96	164	IX 11	Porlom II	”Sture-Porlom” Tornimäki	60 42 17	26 00 12	Finland	**13**
97	163	IX 10	Porlom I	Lille-Porlom	60 42 02	26 00 15	Finland	
98	162	IX 9	Mustila		60 43 31	26 21 47	Finland	
99	161	IX 8	Korsmalm		60 35 12	26 11 21	Finland	
100	160	IX 7	Lovisa	”Kuckusten”	60 26 45	26 13 52	Finland	
101	159	IX 6	Strömfors		60 31 18	26 25 50	Finland	
102	158	IX 5	Kokko-vuori		60 27 41	26 47 44	Finland	
103	157	IX 4	Tuskas		60 22 57	26 33 12	Finland	
104	157	IX 3	Svartvira	Mustaviiri	60 16 35	26 36 12	Finland	**14**
105	158	IX 2	Ristisaari		60 18 51	26 48 51	Finland	
106	156	IX1/VIII14	**Mäki-päälys**	Mäkipäällys	60 04 27	26 58 11	Russia	**15**
107	154	VIII 13	Hohenkreutz	Pikaristi	59 25 10	26 40 40	Estonia	
108	153	VIII 12	Halljall	Haljala	59 25 54	26 16 05	Estonia	
109	152	VIII 11	Warres-mäggi	Varesemägi	59 18 35	26 33 39	Estonia	
110	151	VIII 10	Lewala	Levala	59 15 47	26 17 25	Estonia	
111	150	VIII 9	Raekűll	Raeküla	59 09 28	26 22 17	Estonia	
112	149	VIII 8	Tammik		58 59 30	26 20 20	Estonia	
113	148	VIII 7	Ebbafer	Ebavere	59 06 14	26 13 15	Estonia	
114	147	VIII 6	Marien-Magdalenen	Koeru	58 57 51	26 01 49	Estonia	
115	146	VIII 5	Sall	Salla (Emumäe)	58 56 15	26 22 26	Estonia	
116	144	VIII4/VII4	Oberpahlen	Põltsamaa	58 39 17	25 58 05	Estonia	
117	144	VIII3/VII3	Arrohof	Arumoisa (Aru)	58 16 49	26 22 29	Estonia	
118	146	VIII2/VII2	Kersel	Kaarepere	58 39 33	26 29 54	Estonia	
119	145	VIII1/VII1	**Dorpat**	Tartu Tähetorn	58 22 44	26 43 12	Estonia	**19**
120	143	VII 5	Holstfershof	Holstre	58 17 35	25 43 23	Estonia	
121	142	VII 6	Annikatz	Anikatsi	58 08 32	25 45 20	Estonia	
122	141	VII 7	Arrol	Arula	58 02 59	26 19 33	Estonia	
123	140	VII 8	Helmet	Helme	57 59 43	25 52 54	Estonia	
124	139	VII 9	Lenard	Leenardi	57 59 01	26 21 23	Estonia	
125	138	VII 10	Hummelshof	Hummuli	57 52 58	26 00 58	Estonia	
126	137	VII 11	Mario-mäggi	Essemäe	57 38 17	26 23 41	Estonia	
127	136	VII 12	Oppekaln	Apekalns	57 32 59	26 54 13	Latvia	
128	135	VII 13	Palzmar		57 27 32	26 12 11	Latvia	
129	134	VII 14	Kortenhof		57 17 10	26 46 31	Latvia	
130	133	VII 15	Ramkau		57 10 26	26 08 58	Latvia	
131	132	VII 16	Nessaule-kalns		56 57 37	26 11 05	Latvia	
132	131	VII 17	Elkas-kalns		57 05 00	25 35 28	Latvia	
133	130	VII 18	Gaissa-kalns		56 52 12	25 57 34	Latvia	
134	129	VII 19	Sestu-kalns	Sestukalns	56 50 24	25 38 12	Latvia	**20**
135	121	VII20/VI21	Dabors-kalns		56 35 03	25 41 31	Latvia	
136	127	VII21/VI22	Kreutzburg		56 30 41	25 51 31	Latvia	
137	126	VII22/VI23	**Jakobstadt**	Jēkabpils	56 30 05	25 51 24	Latvia	**21**
138	123	VI 20	Bristen		56 34 53	25 21 34	Latvia	
139	122	VI 19	Arbidäni		56 28 58	25 37 45	Latvia	
140	121	VI 18	Daudsewas		56 28 27	25 13 03	Latvia	
141	120	VI 17	Urmen		56 15 24	25 32 20	Latvia	
142	119	VI 16	Pilkaln		56 11 37	25 09 32	Latvia	
143	118	VI 15	Chanuschischki	Ganusiski	56 08 46	25 31 48	Lithuania	
144	117	VI 14	Ponedeli	Pandėlis	56 01 43	25 13 26	Lithuania	
145	116	VI 13	Jakschti	Jokšiai	55 55 55	25 08 47	Lithuania	
146	115	VI 12	Karischki	Gireišiai	55 54 09	25 26 12	Lithuania	**22**
147	114	VI 11	Martintschuni	Martinčiūnai	55 43 28	25 37 25	Lithuania	
148	113	VI 10	Kinderti	Kinderiai	55 46 27	25 06 30	Lithuania	
149	112	VI 9	Lipsk	Kuzmiškis	55 32 22	25 23 46	Lithuania	
150	111	VI 8	Stworänzi	Storiai	55 29 19	25 08 60	Lithuania	
151	110	VI 7	Tschiwili	Čivyliai	55 19 06	25 28 13	Lithuania	

152	109	VI 6	Bolniki	Petrikiškiai	55 16 58	25 09 13	Lithuania	
153	108	VI 5	Ambroschischki	Ambraziškiai	55 08 24	25 18 24	Lithuania	
154	107	VI 4	Kongedi	Kangedai	55 06 31	24 46 54	Lithuania	
155	107	VI 3	Meschkanzi	Meškonys	54 55 51	25 19 00	Lithuania	**23**
156	106	VI 2	Naborowtschisna	Nuobariškės	54 42 15	24 47 60	Lithuania	
157	104	VI1/V29	**Nemesch**	Nemėžiš (Nemez)	54 39 01	25 19 00	Lithuania	
158	105	V 28	Chorunschischki	Šventininkai	54 51 43	25 37 44	Lithuania	
159	102	V 27	Beresnäki	Paliepiukai	54 38 04	25 25 45	Lithuania	**24**
160	101	V 26	Konradi		54 42 09	25 45 48	Belarus	
161	100	V 25	Medniki	Medininkai	54 31 52	25 37 40	Lithuania	
162	99	V 24	Deibissi		54 31 32	25 56 02	Belarus	
163	98	V 23	Tupischki		54 17 30	26 02 43	Belarus	**25**
164	97	V 22	Loitzi		54 18 31	25 48 07	Belarus	
165	96	V 21	Widnopol		54 07 24	25 52 18	Belarus	
166	95	V 20	Daukni		54 02 51	25 26 35	Belarus	
167	94	V 19	Iwje		53 58 27	25 44 37	Belarus	
168	-	-	Tscherniki (Ext stn)		53 57 09	25 13 12	Belarus	
169	93	V 18	Amalienhof		53 42 52	25 51 35	Belarus	
170	92	V 17	Dokudowo		53 48 50	25 30 37	Belarus	
171	91	V 16	Putzewitschi		53 36 07	25 46 25	Belarus	
172	90	V 15	Falkowtschisna		53 44 12	25 15 53	Belarus	
173	89	V 14	Lopati		53 33 38	24 52 11	Belarus	**26**
174	88	V 13	Tarassowzi		53 25 15	25 26 37	Belarus	
175	87	V 12	Solotejewo		53 14 48	24 52 29	Belarus	
176	86	V 11	Dsergeli		53 05 49	24 45 19	Belarus	
177	85	V 10	Rinki		53 04 19	25 09 03	Belarus	
178	84	V 9	Marinus		52 56 17	25 30 33	Belarus	
179	83	V 8	Schomeizäki		52 46 50	25 03 37	Belarus	
180	82	V 7	Iwazewitschi		52 43 28	25 19 16	Belarus	
181	-	-	Ssoschitza (Ext. stn)		52 36 05	24 50 20	Belarus	
182	81	V 6	Bronna		52 35 59	25 05 11	Belarus	
183	80	V 5	Gath		52 34 05	25 37 12	Belarus	
184	-	-	Winin (Extra stn)		52 27 10	24 52 02	Belarus	
185	79	V 4	Ossownitza		52 17 22	25 38 58	Belarus	**27**
186	79	V 3	Leskowitschi	Leskovichi	52 09 39	25 34 17	Belarus	**29**
187	80	V 2	Besdesch		52 19 31	25 17 07	Belarus	
188	78	V1/IV1	**Belin**		52 02 39	25 13 03	Belarus	
189	76	IV 2	Bolschaja-Gluscha		51 48 31	25 01 46	Ukraine	
190	77	IV 3	Schlapan		51 52 27	25 28 26	Ukraine	
191	75	IV 4	Tscherwischtsche		51 34 55	25 24 52	Ukraine	
192	74	IV 5	Gutakamenskaja		51 34 45	25 01 54	Ukraine	
193	73	IV 6	Tscheremoschna		51 20 11	25 03 53	Ukraine	
194	72	IV 7	Datin		51 31 10	24 43 03	Ukraine	
195	71	IV 8	Kowel		51 14 49	24 42 57	Ukraine	
196	70	IV 9	Golobi	Holoby	51 06 50	24 59 46	Ukraine	
197	69	IV 10	Osmigowitschi	Os'myhovyci	50 54 33	24 46 41	Ukraine	
198	68	IV 11	Roschischtsche	Rozysce	50 55 45	25 15 56	Ukraine	
199	67	IV 12	Tortschin	Torcyn	50 44 03	24 59 34	Ukraine	
200	66	IV 13	Krupi		50 41 04	25 24 45	Ukraine	
201	65	IV 14	Schabtscha		50 27 48	25 07 23	Ukraine	
202	64	IV 15	Smordwa		50 25 19	25 30 55	Ukraine	
203	63	IV 16	Borbin		50 40 21	25 44 31	Ukraine	
204	62	IV 17	Gurniki		50 23 05	25 50 40	Ukraine	
205	61	IV18/III1	**Kremenetz**		50 05 45	25 41 47	Ukraine	
206	59	III 2	Matwejewzi	Matviivci	49 58 15	25 58 36	Ukraine	
207	59	III 3	Mosty		50 11 50	26 00 03	Ukraine	
208	58	III 4	Ssiwki	Syvky	50 01 29	26 15 56	Ukraine	
209	57	III 5	Beloserka	Bilozirka	49 46 15	26 14 08	Ukraine	
210	56	III 6	Turowka		49 52 41	26 30 39	Ukraine	
211	55	III 7	Basalia	Bazalija	49 41 22	26 28 58	Ukraine	
212	54	III 8	Montschinzi		49 43 48	26 48 21	Ukraine	
213	53	III 9	Katerinowka		49 33 57	26 45 22	Ukraine	**31**
214	52	III 10	Kriwotschinzi		49 29 06	26 27 33	Ukraine	
215	51	III 11	Felschtin		49 19 48	26 40 55	Ukraine	**32**

216	50	III 12	Alexandrowka	Oleksandrivka	49 16 41	26 18 60	Ukraine	
217	49	III 13	Tschernowody	Cornyvody	49 08 05	26 38 00	Ukraine	
218	48	III 14	Baranowka		49 08 55	26 59 30	Ukraine	**33**
219	47	III 15	Hanowka		48 55 45	26 51 32	Ukraine	
220	46	III 16	Karatschkowzi		48 53 49	26 32 51	Ukraine	
221	45	III17/II22	**Ssuprunkowzi**		48 45 03	26 47 52	Ukraine	
222	42	II 21	Sagorjane		48 44 26	27 07 10	Ukraine	
223	41	II 20	Woltschenetz		48 28 07	26 55 05	Ukraine	
224	40	II 19	Britschani	Brinceni	48 20 39	27 07 15	Moldova	
225	39	II 18	Gwosdautzi		48 25 45	27 18 47	Moldova	
226	38	II 17	Rotunda		48 14 27	27 19 09	Moldova	
227	37	II 16	Lipnik	Lipnic	48 22 24	27 30 50	Moldova	
228	36	II 15	Rudy	Rudi	48 19 08	27 52 36	Moldova	**30**
229	35	II 14	Tyrnowo	Tirnova	48 09 57	27 38 26	Moldova	
230	34	II 13	Boksano		48 07 17	28 04 15	Moldova	
231	33	II 12	Ketros		47 59 14	27 49 21	Moldova	
232	32	II 11	Belzy		47 50 03	27 56 54	Moldova	
233	31	II 10	Wodeni	Vadeni	47 59 23	28 12 47	Moldova	
234	30	II 9	Unkiteschti		47 53 44	28 29 45	Moldova	
235	29	II 8	Tschutuleschti	Ciutulesti	47 45 16	28 19 29	Moldova	
236	28	II 7	Rospopeni	Rospopeni	47 43 30	28 38 19	Moldova	
237	27	II 6	Sagaikani	Saratenii	47 29 37	28 31 19	Moldova	
238	26	II 5	Bologan		47 27 38	28 50 02	Moldova	
239	25	II 4	Ziganeschti	Tiganesti	47 19 05	28 32 52	Moldova	
240	26	II 3	Peressetschino	Peresecina	47 15 51	28 47 28	Moldova	
241	25	II 2	Ssurutscheni	Truseni	47 03 58	28 39 27	Moldova	
242	24	II1/I1	**Wodolui**	Vadul lui Voda	47 01 22	29 04 16	Moldova	
243	22	I 2	Dschamana	Geamana	46 47 24	29 12 36	Moldova	
244	23	-	Reseni	Razeni	46 42 58	28 52 08	Moldova	
245	21	I 3	Ploska		47 00 60	29 38 45	Ukraine	
246	20	I 4	Nowokauschani	Causeni	46 37 18	29 27 39	Moldova	
247	19	I 5	Nesselrode		46 27 52	29 06 36	Ukraine	
248	18	I 6	Nikolajewka	Mykolaivka	46 20 37	29 24 57	Ukraine	
249	17	I 7	Kulmskaja		46 15 43	29 01 17	Ukraine	
250	16	I 8	Baschkalia	Bascalia	46 19 29	28 48 33	Moldova	
251	15	I 9	Baurtschi	Baurci	46 07 02	28 42 11	Moldova	
252	14	I 10	Malojaroslawetzkaja	Malojaroslavec	46 05 21	28 58 37	Ukraine	
253	13	I 11	Taraklia	Taraclia	45 54 58	28 45 32	Moldova	
254	12	I 12	Kamboli		45 58 39	28 31 12	Moldova	
255	11	I 13	Bolgrad	Bolhrad	45 47 39	28 39 03	Moldova	
256	10	I 14	Pandaklia		45 46 56	28 54 48	Ukraine	
257	9	I 15	Karakurt		45 37 52	28 43 36	Ukraine	
258	8	I 16	Katlabuch		45 36 43	28 55 57	Ukraine	
259	7	I 17	Katlabuch-ssuchoi		45 29 33	28 54 53	Ukraine	
260	6	I 18	Taschbunar II		45 33 55	28 50 23	Ukraine	
261	5	I 19	Kairaklia		45 28 43	28 46 35	Ukraine	
262	4	I 20	Ssafianowka		45 24 32	28 52 29	Ukraine	
263	3	I 21	Borska	Broska	45 22 16	28 45 37	Ukraine	
264	2	I 22	Ismaïl	Izmail	45 19 57	28 50 39	Ukraine	
265	1	I 23	**Staro-Nekrassowka**		45 19 54	28 55 41	Ukraine	**34**

2. Justification for Inscription

2. (a) Statement of significance

Determination of the figure of the Earth (i.e. its size and shape) has been among the most important problems of natural philosophy since at least Aristotle's time (4^{th} century BC). The development of "triangulation" in the early 17th century was a radical improvement in man's ability to measure the size of the earth. Triangulation was a method of measuring long distances by means of a series of connected triangles forming a "geodetic arc". By knowing the baseline of a triangle and measuring its adjacent angles, it was possible to calculate the distance to the third point (see Appendix I, p 3). Between the 17^{th} and early 20^{th} centuries these basic trigonometric principles allowed geographers to study the figure of the planet by means of indirect trigonometric measurements of the length of parts of meridians and parallels (i.e. lines of longitude and latitude respectively) together with astronomical measurements of their angular amplitudes (see Appendix I, p 3). Such a ground-based technology was an inevitable and important stage in the history of astronomy, geodesy and cartography resulting in the achievement of highly reliable and widely used values for the dimensions of the Earth. More recently the technology changed with the introduction of special satellites designed to assist in the measure of global or regional geometric parameters of the planet at precisions of centimetres. The original technology has become generally obsolete and has left to the history of science its remarkable features such as comprehensive cooperation between monarchs, scientists, surveyors and instrument makers, difficulties of field measurements of substantial duration in all geographical zones and under various political circumstances, with diseases and deaths of workers, errors and problems of conjunction of different results and the introduction and adoption of a single length unit.

Scientific significance

The history of the 40-year-long effort for the measurement of the Arc (1816-1855) reveals an important multiple interchange of human values of East and West Europe regarding developments in science and technology, namely, astronomy, geodesy and cartography and the effects of the results of mapping on the population in general. Interchange and appreciation of important achievements in those fields was both direct and indirect. A rich variety of educational, scientific, technological, personal and official contacts were established before and during the measurements. These involved prominent European Heads of State, statesmen and scientists such as the Monarchs of Russia, Alexander I and II and Nicolaus I; and of Oskar I of Sweden and Norway; astronomers Struve, Bessel, Gauss and Airy; military surveyors Tenner, Volkonski and Schubert, instrument and clock makers Fortin, Baumann, Repsold, Reichenbach, Ertel, Dent, Troughton, and national officials of the Governments from both sides of Europe.

Technical significance

No proper map of a country can be made without a framework of triangulation stations each of accurately known position (see Appendix I, p. 3). All map detail is hung on to such a framework like putting the flesh on to a skeleton. Any such framework depends on good knowledge of the size and shape of the earth and hence the essential importance of Arcs such as that of Struve.

From the technical point of view, the Arc is outstanding in its length, the precision of its measurement, and of the special type of technology required. It stretches over 2820 km through Scandinavian and East-European territories and consists of some 300 adjacent triangles forming a chain where the triangle side lengths are often greater than 50 km. Triangulation as a method to measure long distances was vital in the multi-century history of experimental study of the figure of the Earth by means of ground-based observations performed by various nations and underpinned accurate mapmaking on a continental scale.

The Indian example carried out by William Lambton and George Everest was funded by the East India Company to facilitate trade and it was the requirement for good mapping that led Struve to expand on his initially minor work in Livonia. (Livonia was later divided between Estonia and Latvia).

The Struve Arc is of considerable scientific importance because of its category of feature:

- It was the first meridian arc measurement to cross multiple international boundaries and in today's terms it passes through the ten countries of Norway, Sweden, Finland, Russian Federation, Estonia, Latvia, Lithuania, Belarus, Republic of Moldova and Ukraine, all of which are adherents to the World Heritage Convention.
- Such features were of increasing importance in areas of science particularly in relation to knowledge of the size and shape of the earth, in navigation, astronomy and cartography. Such knowledge was important for improved navigation at sea, in determining distances to heavenly bodies and in ensuring that maps correctly depicted the positions of the multiplicity of features represented on them.
- It was, at 2820 km, the longest at the time of its completion, stretching from near the North Cape in Norway to the Black Sea. The only arc to well exceed it for length was not completed until 1954 by which time the technology used was vastly different to that available in the time of Struve.
- It used the best equipment available at that period with some items made especially for the scheme. The theodolites were mostly capable of resolving a single second of arc (= 1/1296 000 of a circle).
- It was observed with an exceptional order of precision for work in the early 1800s. As detailed in the Appendix I the accuracy achieved in all the various sections was of the highest order. The overall figure quoted by Struve of 1/232,390 is equivalent to about 4 mm in every km over a distance of 2820 km.
- From its completion it was important for national mapping schemes in the countries it went through.
- It forms a reference frame for subsequent fundamental work throughout the countries of Central Eastern Europe.
- The preservation of some of its points allows a basis for later research work particularly in the field of plate tectonics.
- It has frequently featured in scientific investigations from those of Bessel in 1834, who incorporated the results from some of the completed sections of the Struve Arc in his determination of the figure of the earth based on all data available at that time, to those of the geodesist Zhongolovich in 1957 at the beginning of the satellite era. In addition George Airy in 1845 used a section of the Struve Arc that he called "excellent" in his calculation of the earth parameters from 18 different arcs and George Everest in 1847 used 4 sections of the Struve Arc when determining the best parameters for the earth from 12 arcs. It should be pointed out that the more good quality arc values that can be included in a computation the better the result should be.

Thus, the survival of major elements of the submitted feature bears testimony to its exceptional quality and real significance.

As will be seen in the documentation, such works can be traced back to 230 BC but it was not until the early 17th century that techniques of sufficient reliability were invented and gradually improved in the accuracy with which they could be used to meet the increasing requirements of the areas mentioned above.

By the time of Isaac Newton (1642-1727) it was known that the earth was not flat nor was it a perfect spherical shape but there was controversy as to whether it was a sphere elongated or flattened at the Poles (see Appendix I, p 5). Solving this problem was urgent by the early 1700s since Newton had suggested, solely from his theoretical calculations, that it was flattened whereas in France the astronomers (who were also the surveyors of the time) said it was elongated. Expeditions sent in the 1730s to Peru and Lapland were to eventually prove Newton to be correct. Parts of the work by Maupertuis from the French Academy of Science on the Lapland Arc are incorporated in the Struve Arc.

No national or international mapping could proceed properly without knowledge of the size and shape of the earth and as trade, exploration and general travel by sea increased so continuing improvements in navigation were required. Mapping and navigation in turn depend on such features as the Struve Arc having increased length and quality to give ever-increasing accuracies in the required parameters. Major schemes for transportation routes, astronomy, offshore oil exploration and development in general are heavily reliant on reliable mapping.

A simple example of the need for good knowledge of the size of the earth is that if Christopher Columbus had used better starting data he would not have gone where he did. By working with a figure that was some 25 percent too small he had a distorted idea of the earth upon which he was navigating. It was almost as though he thought he was going round a tennis ball when in fact he was on a flattened football. Not only would he be using incorrect distances but incorrect directions as well. Sailing in a direction that was incorrect by just 1º would mean that after 1000 km he was over 17 km out of position laterally. That is perhaps an over-simplification but illustrates the dilemma.

Future importance

In addition to the various attributes that led to the originating of the feature in question there is also the future use. Scientists use very long term observations to evaluate and monitor, for example, the movements of tectonic plates and of earthquake zones. Survey stations that were positioned a long while ago to a high order of accuracy supply vital comparative information for modern and future studies in such areas as tectonic movements. A new survey through the selected points using modern satellite technology would provide a further set of epoch values to be available to future researchers.

The definition of the length of a metre in the 1790s was founded upon Arc measurements in France and Peru with a definition that it was to be 1/40 millionth of the circumference of the earth measured through the poles. Such were the inaccuracies of that period that within a matter of just a few years more reliable measurements would have given a different value for the definition of this international standard. That does not invalidate the metre in any way but highlights the fact that continuing improvements in instrumentation made better measurements of the earth's size possible.

2. (b) Possible comparative analysis (including state of conservation of similar sites)

Uniqueness

No other geodetic arcs are presented on the World Heritage List. Globally there are only four geodetic arcs that rank as of anywhere near similar importance. These are in Peru (1735-1745), N. France to the Mediterranean Sea (1791-1799), India (1800-1843) and Eastern Africa from Egypt to S Africa (1879-1954). These can be directly compared with the Struve Arc as shown in the Table of Arcs (see Table 2 on next page). There is no data available as to whether these other arcs provide surviving marks of such great number and geographical extent as in the ten countries of the Struve Arc.

The Table of Arcs details the most notable of these features from 1615 onwards but until the mid 1700s the sophistication in the equipment used (i.e. the effects of sources of error) amounted to more than the quantities that it was necessary to distinguish. In fact it was not until the early 1800s that developments in instrument construction (for example, the mechanical, rather than manual, graduation of circular protractors) reduced the magnitude of error sources and hence increased the accuracy of the results obtained.

Table 2. **Table of Meridian Arc Measurements**

Date	**Observer**	**Location**	**Length of Arc**	**Mid Latitude**	**Length of 1º (m)**
Early Methods					
230 BC	Eratosthenes	Egypt	7º12´	27º40´N	128 500
724 AD	I Hsing	China	32º	35º N	157 520
820	Al Mamun	Iraq	2º	35º N	111 000
1525	Fernel	France	1º	49º20´N	110 600
1580	Brahe	Sweden	0º22´	56º N	112 840
Introduction of Triangulation					
1615-1616	Snellius	Holland	1º12´	52º N	107 400
1633	Norwood	England	2º28´	52º49´N	111 920
1645	Riccioli & Grimaldi	Italy	19´	44º34´N	119 800
1668	Picard	France	1º23´	49º10´N	111 210
1681-1701	Cassini I & II	France	6º19´	49º10´N	111 280
1718	Cassini II	France	2º12´	49º56´N	111 010
1736-1737	Maupertuis	Lapland	1º02´	66º20´N	111 950
1738	Maupertuis	France	1º02´	49º10´N	110 950
1739-1740	Cassini III & LaCaille	France	8º30´	45º15´N	111 240
1734-1742	Cassini II & III	France	8º20´	46º30´N	111 210
1735-1745	**La Condamine**	**Peru**	**3º07´**	**01º31´S**	**110 655**
1751	Boscovich & Maire	Italy	2º10´	43º N	111 027
1752	La Caille	S Africa	1º13´	33º08´S	111 165
1766	Mason & Dixon	America	1º	39º12´N	110 670
1769	Liesganig	Hungary	3º	45º55´N	110 863
1791-1799	**Delambre & Mechain**	**France**	**9º40´**	**46º12´N**	**111 133**
1800-1821	Lambton	India	9º54´	09º35´N	110 601
				13º07´N	110 629
				16º35´N	110 664
1820-1830	Everest I	India	15º58´	13º06´N	110 634
				19º35´N	110 721
				22º37´N	110 904
1823-1843	**Everest II**	**India**	**21º21´**	**23º47´N**	**110 759**
				26º49´N	**110 837**
1816-1855	**Struve**	**10 countries**	**25º20´**	**58º00´N**	See Appendix I, pp. 20-21

Notes for Table of Meridian Arc Measurements:
- **Mid Latitude** is the mean value of the latitudes of the end points of the arc.
- **Length of 1º** is the calculated length of that piece of arc in metres. This value should steadily decrease from the pole to the Equator (see Table of Length of 1º in Appendix I, p 20).

Whereas until the early 1800s the longest arc that had been measured in any way was less that 10º in extent, with the improvement in instrumentation and methodology this suddenly more than doubled during the first half of the 19th century. First Lambton and Everest in India and then Struve covered more than 20º. However, whilst the arc of Lambton and Everest was all within one country, that of Struve and his colleagues spanned 10 countries (in terms of today's international boundaries).

All of the countries through which the Struve Meridian Arc passes from the Arctic Ocean to the Black Sea had their own special problems which when brought together illustrate the magnitude of the results achieved.

Norway accomplished the most northerly arc measurement in history, and the obelisk at Fuglenes marking the overall achievement is a constant reminder.

Swedish surveyors covered ground that had twice previously had short Arc measurements attempted. Any previous uncertainties were resolved with this third visit.

Finland had the arc segment that took a very long time to complete but was only second longest in length. (Today the longest part - more than 1000 km - of the arc spans through Finland.) This was because it was measured through the difficult country of the Finnish forests and swamp. The Arc here also brought together the Russian Tsars and the King of Sweden and Norway, both of whom contributed to the work as acknowledged in the dedication page of Struve's final account, and in the inscriptions on the terminal monuments of the arc (see Figures xx, p 46 and xx, p 70).

Russia, with the island of Gogland, keeps surviving evidence to the solution of the difficult task of bridging the 100 km stretch of Sea between Estonia and Finland.

Estonia supplied the meridional origin at Tartu (Dorpat) that was retained for 40 years. Struve's Baltic arc segment reached the Latvian river Daugava (Duna) and was connected in the south to the arc segment of the Russian surveyor General Carl Tenner.

Latvia was the site of the problems created by the coming together of measurements based on two different standards -the Russian-English sajene (7-feet Tenner's standard) and the Russian-French toise (6-feet Struve's standard). The German astronomer Wilhelm Bessel passed favourable judgement on the solution to this problem by using the combined Struve-Tenner arc in several of his derivations of the Earth's reliable geometry.

Lithuania had the longest baseline of 11,8 km. measured with an apparatus that forced the observers, Tenner among them, to read the scales, thermometer and contact-sliding rule from a kneeling position.

Belarus retains the terminal points of the Ossownitza baseline measured with the same Tenner equipment as that in Lithuania.

Ukraine and Moldova have the longest arc segment by distance, although because of the more favourable topographical circumstances it took only half the time of the section through Finland. Unfortunately, Struve's suggestion to expand the measurement further south does not appear to have been realized within the same century because of political unrest in the region.

2. (c) Authenticity/Integrity

Originally there were altogether 265 main and over 65 subsidiary station points in the whole meridian Arc. Some of them were not marked permanently and thus were lost after Struve's time. However, many are still substantially as they were in Struve's time. Some of points have been completely destroyed due to human activities or at least are now buried under modern building constructions. A selection of surviving station marks, totally 34 sites in the ten countries through which the Struve Geodetic Arc goes will form together a single trans-boundary nomination for linked cultural and natural properties for inscription on the World Heritage List.

All the components involved in this submission have been recovered, their positions proved by historical documents and applying modern techniques to be original, and, in some cases, re-monumented to modern requirements. The modern techniques include the use of both electronic and satellite facilities to ensure that the component items have been correctly located. The criteria used in determining authenticity were:

(a) Is the mark found of the form expected? i.e. does it conform to any known description of the original.
(b) Does modern technology (e.g. GPS or electro-magnetic methods of distance and angle measure) give its position comparable to that of Struve's value?
(c) Is the mark firmly in position? i.e. is there any sign of past disturbance of the marker?

It might well be asked why only a selection of the points and not all of the 265 main stations are being suggested. There are a variety of reasons such as:

- some no longer exist,
- some may still be there but have so far not been found and
- it would not be practical to include them all because of the vast costs that would be entailed in location, renovation and guardianship.

Modern technology can confirm to a centimetre or so that a mark is where it was originally placed or for all practical purposes, has not been moved since it was installed.

Selection of the points to be used depended on various factors such as: ease of location and recovery after, in some cases, 150 years of burial, ease of access both for the work of recovery and for future visitors and cost of preservation, willingness of the local community to take an interest, importance of the point in the overall scheme and maintenance of a reasonable spread of points throughout the complete chain of triangles.

2. (d) Criteria under which inscription is proposed (and justification for inscription under these criteria)

The Operational Guidelines for the Implementation of the World Heritage Convention quote that *"a site which is nominated for inclusion in the World Heritage List will be considered to be of outstanding universal value for the purpose of the Convention when the Committee finds that it meets one or more of the (six) criteria*". The Struve Geodetic Arc meets four of the criteria, as follows:

Cultural Criterion (ii): *The site should exhibit an important interchange of human values, over a span of time or within a cultural area of the world, on developments in architecture or technology, monumental arts, town-planning or landscape design.*

(ii) The Arc exhibits an important interchange of expertise in the development of science and technology between East and West Europe since it brought together scientists from Norway, Sweden, Finland, Russia, France, and Germany. Not only did they exchange their scientific knowledge but also worked in close cooperation to ensure consistency throughout the whole project. In addition they were using state-of-the-art technology but putting it to use in such a way that the results would considerably assist developments in other fields. It was a period when good knowledge of the size and shape of the earth affected navigation in particular but also the progress of large scale mapping of major countries throughout the world and was of importance to astronomers in their work on calculating the distances to far away heavenly bodies.

As technology advanced so the accuracy expectations of travellers, astronomers, cartographers and others similarly increased. The work of Struve and his colleagues was a major step in this progress.

Cultural Criterion (iii): *The site should bear a unique or at least exceptional testimony to a cultural tradition or to a civilization, which is living or which has disappeared.*

(iii) The Meridian Arc bears an exceptional testimony over almost three centuries of measuring the planet by means of ground-based trigonometric and astronomical observations along lines of longitude. A small part of the meridian arc in question had been measured in 1736-37 by Pierre Maupertuis assisted by, among others, Anders Celsius (of thermometer fame) and the renowned mathematician Alexis-Claude Clairaut. That work extended from Tornio (65º 50' N) to Kittisvaara (66º 47'N) or a little less than 1 degree of arc or 107 km. In 1805 this was extended by Jöns Svanberg southwards to Mallören (65º31' N) and northwards to Pahtavaara (67º08' N) or a separation of 1º37' of arc, it is nearly 181 km.

Within a few years Wilhelm Struve started on the arc that bears his name and with the aid of others such as Carl F. Tenner, Nils Haqvin Selander and Christopher Hansteen made observations from the Black Sea (45º20' N) to near North Cape (70º40'N) a distance of 25º20' = 2820 km.

At the time this was achieved it was the longest such measurement over the earth. Granted an arc was being measured in India during the same period by William Lambton and George Everest but that stretched to 2364 km and was all within a single country. In fact it would be a further 100 years before a comparable multi-country arc of nearly 64º was completed through Eastern Africa.

Cultural Criterion (iv): *The site should be an outstanding example of a type of building or architectural or technological ensemble or landscape, which illustrates significant stages in human history.*

(iv) The Struve Geodetic Arc was of such paramount importance in man's knowledge of the parameters of the earth not only to improve navigation but also to provide the basis of accurate mapping of the ten countries through which it passed. So important was this project that it was actively supported by the King of Sweden and Norway and the Tsar of Russia and necessitated close cooperation at cultural and technological levels. Its 2820 km of triangles running more or less along a meridian of longitude has many markers surviving from the time they were originally observed.

Cultural Criterion (vi): *The site should be directly or tangibly associated with events or living traditions, with ideas, or with beliefs, with artistic and literary works of outstanding universal significance.*

(vi) The Arc points are tangibly associated with an event of outstanding universal significance, which was a direct consequence of Sir Isaac Newton's theory that the Earth was not an exact sphere in shape but an oblate spheroid. To substantiate that theory there was a requirement for long distances to be measured in different parts of the world. The longer they were, the better the result should be as far as verifying the earth shape. At the same time the combination of observations from at least two such arcs allowed the size of the earth to be determined.

By preserving a selection of the surviving points under an international umbrella will ensure their availability for future generations of scientists. In particular they provide valuable positional values that will be of great worth to future scientists working in the field of plate tectonics or the deformation of large sections of the earth's surface through volcanic and other similar activities.

Many of the surviving points are now incorporated into the various national triangulation networks of the specific countries. Hence in their way making a vital contribution to the national mapping requirements and at the same time encouraging cross borders cooperation.

Struve ordered special improvements to be made to existing instrumentation such that the highest possible standards of accuracy could be achieved. This led to incorporation of the adaptations into standard equipment.

3. Description

3. (a and b) Description of the property, History and Development

In 1816 F.G.W. Struve, Professor of Mathematics and Astronomy at the University of Dorpat, was put in charge of a trigonometrical survey in Livonia (an area that later was divided between Estonia and Latvia). This was controlled by a baseline on the ice of Lake Werz-Jerw, measured in 1819. During 1820 Struve assisted Gauss in the base measure by Schumacher made near Braack with his new Repsold equipment.

This experience enabled Struve to interest officials in the idea of an arc of about 3½º between Gogland, an island in the Gulf of Finland, and Jacobstadt to the south. After getting the resources he was able to observe the arc between 1822 and 1827.

During more or less the same period (1816-1831) Carl Tenner was doing similar work further south in Lithuania but at that stage he was operating quite independently from Struve.

Once he had completed his early surveys, Struve extended the measurements further north and south so that a very long line would result and could be the basis of a sound set of values for the earth parameters as well as having other uses. Later on also Swedish and Norwegian astronomers connected their work to the project by continuing to make and measure the arc from Tornio in Northern Finland up to Fuglenes in North Norway.

The phases of Arc measurements

First phase Central West Russia 1816 to 1831

c 1816

The early work by Struve had baselines measured with wooden bars and angles by sextant yet even so he got good results. In 1817 Colonel Tenner, who was the previous year charged with the trigonometrical survey in western Russian Provinces, obtained permission (without funds) to also carry out an arc measurement along the Vilnius (Wilna) meridian and started it the same year.

1820-1821

Struve obtained a grant from Dorpat University to fund further arc measurement including development of his own form of base line equipment. He consulted with Schumacher, Bessel and Gauss, and decided to adopt the observing method used by Schumacher on the arc between Denmark and Hannover. He took his reconnaissance northwards from Gogland into Southern Finland together with H. Walbeck, and investigated the country south from the Gulf of Finland.

1822-1827

Struve fitted surveying observations in between his lecturing duties and observing in Dorpat Observatory. Professor Paucker from Mitau (Elgava, Latvia) helped with the astronomical observations at Jacobstadt and Gogland (Hogland). Struve had crossed the larger part of the Gulf of Finland although the connection was difficult: the longest side of the arc triangles he observed from Gogland to the southern shore of the Gulf was in length more than 80 km. In 1827 the chain from Gogland to Jacobstadt (Jēkabpils) was completed, but whilst building substantial signals there were no rocks in which to leave bolts to mark the positions.

When measuring the Simonis base extension in October 1827 the temperature fell to -13ºR (-16ºC).

This triangulation chain incorporated many points of the former Livonia`s astronomic-trigonometric network that was established by Struve himself in 1816-1819. In addition it was necessary to inspect the area north of latitude 59º as far as the Gulf of Finland and to select the locations of points suitable for measurements. In Estonia altogether 20 basic points, auxiliary points (Rakke and Viru-Nigula) and baseline were selected for measurement. Signals needed for sighting to were built. In May 1822, horizontal and vertical angle measurements were started. Fieldwork was completed in the autumn of 1827 with the measurement of Simuna-Woibifer baseline. The baseline was situated in the fields of Avanduse and Võivere estates, where the relief did not impede the measurements. The height difference between the end points of the baseline was 6,3 m and the length of baseline 4,5 km.

1825-1827

Tenner's responsibilities extended into Belarus. He had completed a chain along the meridian of Vilnius (Wilna) from Belin to Bristen tied to baselines at Ossownitza and Ponedeli. As a result Tenner's most northerly point was then only 32 km west of Struve's most southerly station.

1828

The possibility of joining the two arcs brought Struve and Tenner together in Dorpat in early 1828 maybe for the first time where the basis was laid for further cooperation. They were to fight the challenge of incomparability of their two very different units of length before connecting both chains.

Struve and Tenner managed to solve all the problems, and as a result by 1831 there was an arc of 8º02,5' from Gogland to Belin equipped with three base-lines and five astronomical stations with latitude and azimuth observations. The results of the connecting of the two partial arcs were published by the Académie des Sciences in its Mémoires of 1832 and also in vols. VIII and IX of the Annales du Dépôt topographique militaire in 184-1844. It was soon used by Bessel who until 1841 was engaged in computations of improved values of the earth dimensions.

In 1815-1822 Tenner had been assigned by the Russian Military Topographic Department to establish a triangulation network for topographic measurements in the provinces of Vilnius, Kurland, Grodno and Minsk. At Tenner`s suggestion the measurement results of his triangulation network were used for extending the Tartu Meridian Arc southwards and it was agreed to connect to the measurements in Latvia in the area of River Dvina. Considering the major input of Tenner in the measurements of the meridian arc`s triangulation chain, the whole undertaking should perhaps be named Struve-Tenner.

Second phase Extension to the south and north 1830-1844

This began with Struve requesting resources from the Tsar Nicholas I to extend northwards to Tornio. The idea was to connect with the earlier work of Maupertuis and the extension of that by Svanberg.

The military (not only Russian) also had the idea of connections, and Tenner secured three (in 1832, 1843 and 1853) between his, the Prussian and the Austrian geodetic networks, thence to France and the British Isles. This was the first major transcontinental European East-West geodetic framework.

1831

Struve obtained permission to extend northwards and connect with the Lapland arc. Angular measurements were performed by three Finnish officers who had been educated at Dorpat.

1833

In 1833 Struve was commissioned by Nicholaus I to build the best Russian astronomical observatory at Pulkovo.

From 1835 the work was mostly led by a Finnish astronomer Woldstedt, as the officers had been called off for other Russian surveys. Meanwhile Tenner was continuing his geodetic work south of the River Pripyat passing through parts of the Ukraine. His new baseline at Staro-Konstantinow was among the longest in the whole arc. Astronomical observations were made at Kremenetz (lat. 50º 06') and Ssuprunkowzi (lat. 48º 45').

Third phase Sweden and Norway 1844 to 1851 and Bessarabia 1846-1851

Struve had a more complicated task. The first leg across autonomous Finland was not politically difficult. Moreover, he could leave the practical implementation to Woldstedt. Later political steps were needed and the necessary agreements made.

The chain was joined in the north to that part carried out by Sweden as their share. There the responsibility for the work was given to the astronomer N. H. Selander. The chain followed first the old Maupertuis arc of 1736, with western points on the Swedish side and the eastern ones on the Finnish side of the boundary.

Continuing further to the north there was a new political problem. Norway belonged to the Swedish realm but had her own administration. Consequently, the rest of the chain to the Barents Sea was measured under the responsibility of Christopher Hansteen as far as the northernmost point at Fuglenes. This finished the fieldwork. The northern part included 4 additional astronomical stations and 4 baselines.

1844

Struve conferred with scientists from Norway, Sweden and Russia as well as with Tenner, on the possible extension southwards to the Black Sea and for a northern extension to the Arctic. Commissioners were appointed by Sweden and Norway to assess the feasibility - Sweden from Tornio to Kautokeino and Norway from there to North Cape.

Later the same year Struve met with King Oscar I and proposed the extension to the Barents Sea. This was quickly agreed and N. H. Selander was made responsible.

A baseline was measured near Elimä (lat. 60º 50').

1845

Norwegian participation was put in the hands of Christopher Hansteen (1784-1873) Director of the Christiania Observatory.

Astronomical observations were made near Tornio (lat. 65º 51'). A further base (Uleaborg) was measured at Oulu (lat. 65º00'). This then allowed a readjustment of the chain from Tornio to Ssuprunkowzi, an arc of 17º 05' 33''.

13 June saw agreement between Sweden and Norway for the arc to begin. Hansteen despatched two young officers to reconnoitre the area, build signals and determine suitable sites for the baseline and astronomy.

1846 to 1850.

The field observations in Sweden and Norway.

In Bessarabia Tenner continued the triangulation chain as far as the fortress at Ismail, located near the mouth of the river Danube. Two more baselines were measured and two astronomical stations completed. He terminated in the village of Staro-Nekrassowka (lat. 45º20')

Measurements of the Meridian Arc in the territory of Moldova started in August 1846, within the general triangulation frame of "Bessarabia Region". General management was provided by Lt. General Tenner, operational management by Lt. Colonel Hildenband, and from August 1847 by First Lieutenant Napersnikov. Measurements of Moldovian points were completed in 1848. The whole triangulation of this area, including the surveying of the southern part of the meridian arc, is founded on two baselines: Romankauti and Tashbunar, both are in the Ukraine and were surveyed by means of the Struve base equipment. (Details in Struve Arc du méridien de 25º20' entre le Danube et la Mer Glaciele mésure depuis 1816 jusqu'en 1855, Vol. 1 page 37 para 17.) The first of them was adjacent to the border between Moldova and Ukraine and the Moldovian line Gvozdauti-Briceni. Astronomy was provided by Pulkovo astronomer Sabler at the point Vadul-lui Voda in September 1848.

1850

The Alten base was measured by Klouman (1813-1885) and an astronomer, Lindhagen, from Struve's staff at Pulkovo. The area was flat but the base was only 1154,7 t. (2251,7 m). Each terminal was monumented with a stone block, and small iron bolt at the centre.

Bad weather severely delayed the astronomical observations at the northern terminal of the whole arc, Fuglenes near the town of Hammerfest, and Lindhagen just managed to get the last boat south before the permanent winter dark set in. Unfortunately his assistant Lysander died on the long journey back to Pulkovo.

There were 15 stations between Hammerfest and the Finnish border near Kautokeino. The astronomy was at Fuglenes because North Cape itself was unsuitable for the final station because of the weather conditions and persistent fog.

1851-1852

In 1851 a baseline was measured in Öfver-Tornio (Ylitornio) and the astronomy completed at Tornea (Tornio). There were 24 stations in the Swedish section that was mostly observed by Selander, Lindhagen, Skogman and Wagner. The base extension of the Öfver-Tornea base was completed in 1852.

Fourth phase Completion

1852 to 1855

Some supplementary operations like longitude determinations and re-observation of suspect values were made during this period. To honour the completion of the arc, monuments were erected at Staro-Nekrassowka and Fuglenes.

1856-57

Struve published his two volumes of “Arc du Méridien de 25º 20' entre le Danube et la Mer Glaciale mésure depuis 1816 jusqu’en 1855”.

Summary of the Struve Geodetic Arc

The progress of the fieldwork is shown in Appendix I, Table 1.
A summary of the whole arc is as follows:

Northern terminal Hammerfest (Fuglenaes)	latitude 70º 40' 11,23" N*
Southern terminal Ismail (Staro-Nekrassowka)	latitude 45º 20' 02,94" N*
Difference in geographic latitude	25º 20' 08,29"
Difference in toises	1 447 786,783 ± 6,226
Difference in metres	2 821 853,711**
Total number of principal triangles	258
Total number of basic points	265
Total number of base lines	10
Total number of astronomical stations	13

* As quoted in Struve’s volumes.
** This value will vary slightly according to which conversion factor is used.

The monumentation of points

The monumentation of the stations of the Struve Arc varied with different types of marks in different areas. In Finland many were marked on the solid rock by drilling a hole. The hole was filled with lead and on the top of the lead was a plate of brass. Nearly all stations between Hogland and Tornio were marked with small copper plates, which were soldered with lead into 3-6 cm deep holes drilled in the rock or big stones. In the course of time most of the plates have disappeared. In fact most of them were found missing already in the 1890s. Later the lead has been dug out, maybe to be made into shot for the hunters, but the holes have survived in most of Finnish points.

Also in the Swedish-Norwegian part many points were marked directly on the solid rock or on big rocks by engraveing a cross and are still unchanged. Unfortunately, Struve did not leave ground markers at the positions of his stations between Hogland and Jacobstadt except for the two base terminals. Within this section the centre markers were mostly placed on timbers, which have not survived.

The monumentation south of Jacobstadt belongs exclusively to the merits of Tenner. There points were marked on stones or brickwork, which were placed underground to depths of up to a metre.

In general the form of the marks can range from

- a small hole drilled in a permanent rock surface - sometimes filled with lead but often such a filling has been poached for other uses although the hole remains,
- cross shaped centre and/or witness marks engraved in the rock,
- to a solid block with a marker set in it,
- or a large solid structure of rocks possibly some decimetres below ground level, together with a centre stone or brick in which there is a drilled hole,
- a measuring block on top of which was a single brick on edge of which the intersection of the diagonals designated the point. This was used by Tenner on his baselines.

Essentially the marks are similar to, and serve the same purpose as, the triangulation pillars that one finds on hill tops in the many countries where there is a central mark within some larger, stable and reasonably secure structure. With the older marks these are now sometimes found 25 cm or more below ground level but on location, excavation and verification are still in their original condition.

Similar types of mark are often used to locate well-known geographical features such as various national meridians, geographical centres of various sorts and border points between countries and continents. Most of them - unlike the meridian of this submission - are not of particular universal significance or of practical use to a range of professions. They do not bear witness to such a considerable amount of international labour under various climatic, topographic and geographic circumstances, with intensive and multiple interchange of human values based on a rich historical background.

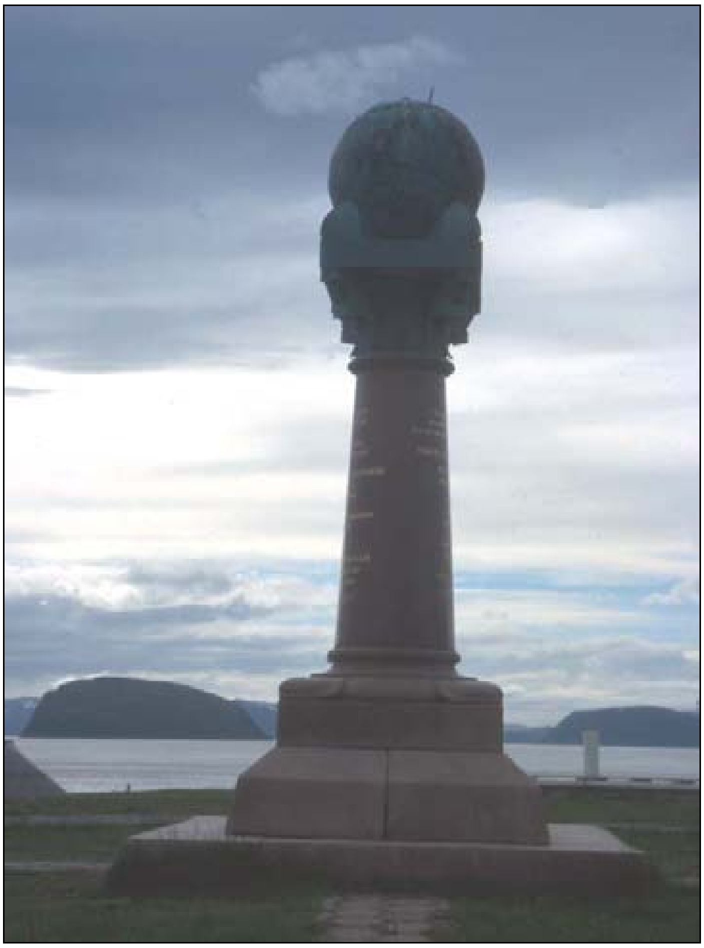
The form of conservation of those comparable properties is similar to that proposed for the selected Struve Geodetic Arc stations: i.e. special plaques or similar noticeboards in the immediate vicinity. Existing linear cultural sites bear a description distributed along the lines and this is also envisaged in the case of the Arc points.

The lengths attainable between neighbouring triangulation points vary according to several factors. These include the range of height of the topography, the vegetation cover and the suitability of points to form reasonably shaped triangles. For the full Struve Arc the longest line is 81,7 km in length (from Mäki-Päälys on Hogland Island to Halljall in Estonia) and many lines are well over 60-70 km long. The shortest line is only 479,6 m in length (from Porlom I to Porlom II in Finland). The average length between points is 27,1 km.

None of the terrain over which the survey was observed could be termed mountainous as in the Peru arc of 1735 (along the Andean peaks) or the Arc of 30th Meridian (the mountains of East Africa). However the terrain varied from massive granite outcrops in the Northern latitudes, some tree covered, through low lying areas in central Finland. To the simple island of Hogland that greatly assisted the crossing from Finland to Estonia but presented poor geometry. Through thickly forested areas of Eastern Europe and the marshlands to the delta of the river Danube where long sight lines were difficult to obtain. Any hills were made use of as well as high buildings available like the tower of Alatornio church and the Observatory at Tartu.

Description, history and Development of the selected sites of the Struve Geodetic Arc

The description of the selected 34 sites is given below. Totally 29 of these points are main points of the Arc. Three of them are baseline points, i.e. Woibifer (17) and Katko (18) are the terminals of the Simonis base in Estonia and Tchekutsk (28) is the SSW terminal of the Ossownitza base in Belarus. Ossownitza (27), the NNE terminal of the Ossownitza baseline is also within the selected points being at the same time one of main points. The point Hogland (16) is the astronomical point Z on the island Gogland in Russia. The point Lille-Reipas (2) is a point in the baseline extension network. In these descriptions some detail is given about the history of the points; when they were built and measured for Struve Arc purposes and what has been their role after that time in surveying and mapping activities. The present situation and development is also described. (Note: The numbers for photos below in site description are those used in the Appendix III, Photographs, for same photos.)



The Monument of the Arc at FUGLENAES.
(Appendix III: **Photo No 1.**)

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1. FUGLENAES (Norway)

Established. 1846
Type of mark. Obelisk built over ground mark in 1854.
Condition. Frequently inspected by local people.
In good order.
Status. First order station in national survey.

The Struve Geodetic Arc station FUGLENAES (present spelling Fuglenes) was marked in 1846 and the final astronomical observations at the point were carried out in 1850. The obelisk is situated in the harbour area at the northern part of Hammerfest city, at the peninsula called Fuglenes. People from Hammerfest Municipality take a keen interest in its preservation.

Since the Arc was measured, the station FUGLENAES has been a first order geodetic station for Norwegian national mapping activities, thus keeping its identity. It was most recently remeasured in 1994. In the Norwegian Mapping Authority's archives this point has the number U02T0002. Hammerfest Municipality has built a small park area around the monument.

The monument to the Struve Arc site is conserved by the Act for Ancient Monuments.

Termius septentrionalis
Arcus meridiani 25° 20′
quem
inde ab Oceano Arctico
ad fluvium Danubium usque
per
Norvegiam, Sueciam et Rossiam
jussu et auspiciis
Regis Augustissimi
OSCARIS I
et Imperatorum Augustissimorum
ALEXANDRI I
atque
NICOLAI I
annis MDCCCXVI ad MDCCCLII
continuo labore
emensi sunt
Trium gentium geometrae.
Latitudo: 70° 40′ 11″,3.

Det nordlige Endepunct
af en Meridianbue paa 25° 20′
fra det nordlige Ocean til Donau-Floden
igjennem
Norge, Sverige og Russland
efter Foranstaltning af
Hans Majestaet Kong
OSKAR I
og Keiserne
ALEXANDER I
og
NICOLAI I
ved uafbrodt Arbeide
fra MDCCCVI til MDCCCLII
udmaalt af
de tre Nationers Geometrer.
Brede: 70° 40′ 11″,3.

Figure 1.
The inscriptions on the monument of the Arc at FUGLENAES; Struve F.G.W. *Arc du méridien de 25º 20' entre le Danube et la Mer Glaciale mésure depuis 1816 jusqu'en 1855.* Tome premier, St Petersburg, 1860.

2. LILLE-REIPAS (Norway)

Established.	1846.
Type of mark.	Cairn over point in bedrock.
Condition.	Cairn replaced by iron marker. In good repair in 1999.
Status.	Point in national survey.

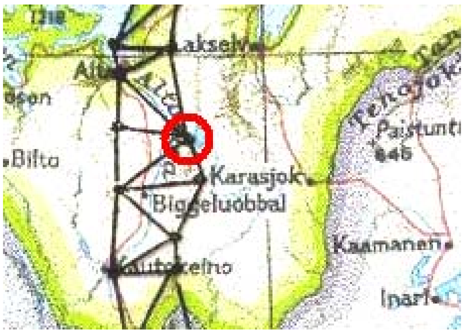
The Struve Geodetic Arc station LILLE-REIPAS is on the bedrock of the mountain Raipas. It is the point E in the extension network for Alta baseline. By starting from the measured baseline the longer distance has been calculated using extension points and observed angles of triangles (see Appendix I, p. 5 for description of base extension).

A report from 1896 explained that a new cairn was built at the same place as the Struve Geodetic Arc station. Today there is no cairn, but an iron marker for trigonometric observations is marking the place of the Struve point from 1846. The site is 4 km south of the runway at Alta airport.

Since the Arc was first measured, the station LILLE-REIPAS has been a geodetic station for Norwegian national mapping activities, thus keeping its identity. It was last remeasured in 1968. In the Norwegian Mapping Authority's archives this point has the number U05T0076.

The Struve Arc site is conserved by the Act for Ancient Monuments.

3. LOHDIZHJOKKI (Norway)



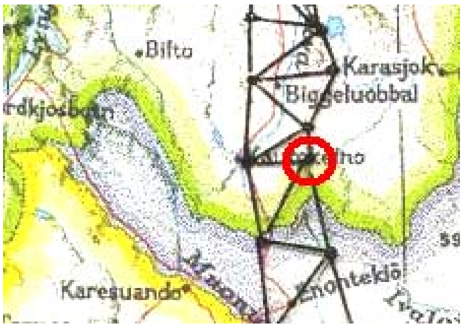
Established.	1846
Type of mark.	Cairn over point in bedrock.
Condition.	Cairn rather delapidated but still in position.
Status.	First order point in national survey.

The Struve Geodetic Arc station LOHDIZHJOKKI (present spelling Luvdiidcohkka) is at a small cairn on the rather flat summit of the hill Luvdiidcohkka. It is situated 2,5 km southeast of the old main road to Kautokeino, near lake Holgajavri. The point is situated above the timberline so there are no trees near the point.

Since the Arc was established, the station LOHDIZHJOKKI has been a first order geodetic station for Norwegian national mapping activities, thus keeping its identity. It has been remeasured on the same spot according to reports in 1867, 1873, 1895, 1902, 1904, 1905, 1909, 1922, 1967 and 1978. A pillar 20 m south of the cairn was built for astronomical observations in 1978. The station was inspected in 1999 and was then in good shape. In the Norwegian Mapping Authority's archives this point has the number U06T0014.

The Struve Arc site is conserved by the Act for Ancient Monuments.

4. BÄLJATZ-VAARA (Norway)



Established.	1846
Type of mark.	Cairn over point in bedrock, rebuilt 1896.
Condition.	Cairn rather delapidated but still in position.
Status.	First order point in national survey.

The Struve Geodetic Arc station BÄLJATZ-VAARA (present spelling Baeljasvarri) is on the rather flat top of the mountain Baelljasvarri, 2.5 km east of the little village Avzi. A report from 1896 explains that a new cairn was built at the same place as the Struve Geodetic Arc station. The point is situated above the timberline so there are no trees near the point.

Since the Arc was measured, the station BÄLJATZ-VAARA has been a first order geodetic station for Norwegian national mapping activities, thus keeping its identity. It has been remeasured on the same spot according to reports in 1896, 1917–21, 1969 and 1977. The station was inspected in 1999 and was then in good shape. In the Norwegian Mapping Authority's archives this point has the number U07T0004. Two additional metal markers where placed within 10 m of the old cairn in 1969 and 1977.

The Struve Arc site is conserved by the Act for Ancient Monuments.

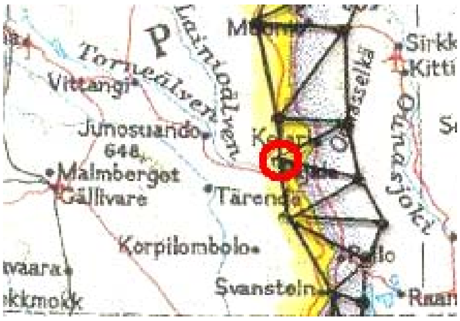
5. PAJTAS-VAARA (Sweden)

Established. 1846
Type of mark. Wooden signal construction.
Condition. Structure still in position.
Status. Point in national triangulation.

The Struve Geodetic Arc station PAJTAS-VAARA is on the mountain called by Struve Pajtas-vaara (present spelling Paittasvaara). The name is misleading, as this is the name of another mountain in the surrounding area. Instead subsequent surveys used the name Pingisvaara and in the 1930s a new name was in use, Tynnyrilaki. This summit is the highest point, 445 m, in the Pingisvaara mountain area.

In 1874-1876 a triangulation was made by Emil Wolyn across-country in northernmost Sweden, starting in 1874 from the Struve Geodetic Arc side Pessinki-Lumivaara and returning in 1876 to the side Stuorraoaivi ("Stuor-oivi") - Tynnyrilaki ("Pajtas-vaara"). Wolyn identified the old signal. Since then the site has been used for Swedish triangulation works.

6. KERROJUPUKKA (Sweden)



Established. 1845
Type of mark. Arc's reference marks no longer exist but central position can be re-located.
Status. Used in national survey.

The Struve Geodetic Arc triangulation station KERROJUPUKKA (present name Jupukka) is located on a hilltop close to the Torne River. Due to geological factors this is a hill with special vegetation and a Nature Preservation Area was instituted in 1977. The top of the hill has been used for grazing and there are few blocks or rock outcrops.

The station was re-used for Swedish triangulation work in the 1870s by Emil Wolyn and is still in use with a modern triangulation close to the place where the measurements for the Struve Geodetic Arc were made.

7. PULLINKI (Sweden)

Established. 1736-37, 1801, 1845.
Type of mark. Position of survey is within the summit area, close to the modern survey mark
Status. Close to the modern national triangulation point

The Struve Geodetic Arc station PULLINKI stands on a steep forested mountain dominating the area surrounding Svanstein parish church. At 335 m it rises more than 250 m above the nearby Torne river. Pullinki was originally made a trigonometrical station when Maupertuis, assisted by the Swede Anders Celsius (of thermometer fame), observed his Arc Measurement in 1736-1737. It was a convenient location as the high mountain is close to the parish church and settlement at Svanstein. When Jöns Svanberg in 1801-1803 observed a new triangulation, Pullinki was included in that chain. The Struve Geodetic Arc was then the third arc measurement made at this point.

The property nearby was in the 1980s turned into a skiing resort area, hotel buildings and a ski lift system was built. A new tourist outlook tower replaced an older one. The top was also familiar with scouts, having a small hut on the place (now demolished). In commemoration of Maupertuis' measurement a monument (pyramid) was erected there in 1985. There are no visible surface marks from the Struve Geodetic Arc as the point is under the monument, but the place is one of the most important sites as it includes all three arc measurements by Maupertuis, Svanberg and Selander for the Struve Geodetic Arc.

8. PERRA-VAARA (Sweden)

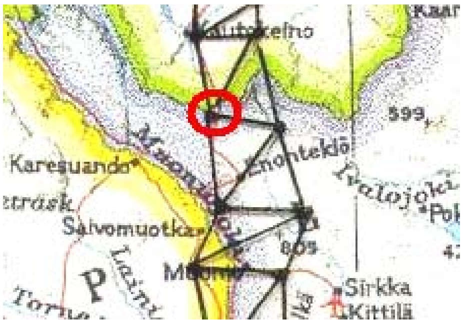
Established.	1845.
Type of mark:	Single cross in rock
Condition.	Well defined
Status.	Modern national survey point is close to the cross-mark

The site of the Struve Geodetic Arc station PERRA-VAARA (present spelling Perävaara) is on Alanen-Perävaara hill that is one of the highest points in the coastal district of eastern Norrbotten county, however it has a rather flat appearance.

In 1922 PERÄVAARA was re-surveyed, but no marks from the SGA could at that time be identified. In later years a single cross-mark (+) from the Struve Geodetic Arc was however located.

The cross-mark of PERÄVAARA.
(Appendix III: **Photo No 13.**)

9. STUOR-OIVI (Finland)

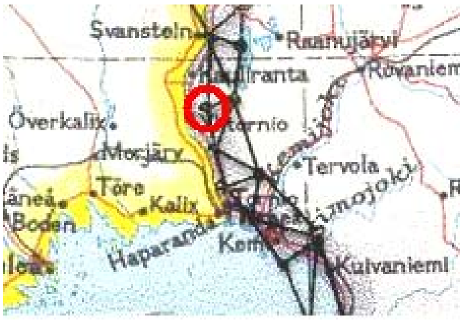


Established.	1850 - 52.
Type of mark.	Struve centre mark replaced 1895 with a bolt.
Condition.	Good order.
Status.	National geodetic point is close to the arc point.

The point of the Struve Arc STUOR-OIVI (present spelling Stuorrahanoaivi) was referenced to a pair of crosses engraved into rocks. Near it another reference cross was engraved in 1852. The crosses are surviving and the authenticity of the point is based on its permanent use and confirmed by direct measurements related to the adjacent triangulation point. No changes have been made in the vicinity of the station. The surrounding area used to make observation and measurements is an open space as it was at the time of the Arc measurements. The centre point was incorporated in the Norwegian triangulation network in the 1895 by a signal and centre bolt.

Since the Arc was measured, the station has been a fundamental geodetic point for Finnish national mapping activities. A first order triangulation point was measured near the same spot in 1970s. This new point is at the distance of 7,60 m to the north of the Arc point. The centre point and the witness marks of the new station exist as well as the markers of Struve Arc.

10. AVASAKSA (Finland)



Established.	1845.
Type of mark.	Cross in bedrock, site monumented in 1970 with a tower.
Condition.	Tower well maintained.
Status.	New triangulation point nearby established in 1969.

The point of the Struve Arc AVASAKSA (present spelling Aavasaksa) was marked with a centre marker and with two witness markers of crosses engraved into the bedrock. In the 1920s these markers were searched for by the geodesists of National Land Survey. They did not recognise them at that time. During recent measurements it has been proven that markers were hidden under a lookout tower built in the year 1969 on the highest site of the hill. On the tower a modern triangulation point and the exact location of the Arc point has been found by measurement to be vertically below a position on the upper deck of the tower.

The chronicler of the de Maupertuis expedition wrote on Aavasaksa on 8th July 1736 as follows: “Mount Aavasaksa is situated in the best peopled and finest part of the river: its bed, above all, towards the south, for the space of four or five leagues, is extremely wide, and offered the most proper spot we could desire for an excellent base, whose extremities would be visible from Huitaperi and Aavasaksa. This base could not be measured at any other time than in winter over the ice; but it suited to fix upon it, and erect signals at its extremities, to join it to the triangles, and to make the necessary observations before winter came on”.

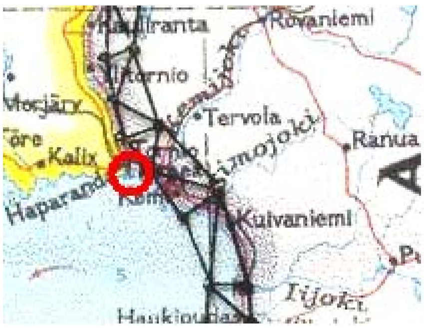
Since Maupertuis’ time Aavasaksa has been famous for its beauty and for the sun at midnight. The area of the Aavasaksa hill belongs to the Nature Conservation area owned by the Finnish State. The position of the Struve Arc point AVASAKSA is about 1,5 m to the west of the present triangulation point.

Pierre Louis Moreau de Maupertuis made an expedition to the Tornionlaakso Valley in 1736 – 1737. De Maupertuis and Camus were the first to set up their instruments on the Aavasaksa hill. As accommodation was available at the Ylitornio, Aavasaksa became the central place for the measurements for Maupertuis' expedition. The angular observations from Aavasaksa to Luppio and Poiki-Torni – end points of the baseline – were carried out at the end of August 1736. Their measuring points were not marked permanently.

In the 19th century the Aavasaksa hill was used for new measurements. Svanberg carried out measurements at the beginning of the century and later on Selander and Lindhagen in connection with Struve Arc measurements. According to documents the point had three markers: one in the centre point of the signal, second one 2,4 French feet* to the west from centre and third one 3,24 French feet* to the east from centre. These points have not been found in investigations during the 20th century, partly because on the rock exist many engravings made by visitors, who like to leave their initials as a memory on the bedrock. (* 1 French ft = 1,0654 English ft of the time).

Aavasaksa is part of a reservation area conserved since 1878 by the Declaration of the Finnish National Board of Forestry (Metsähallitus).

11. TORNEA (Finland)



Established. 1842.
Type of mark. In church tower.
Condition. Well maintained.
Status. Point in the survey of Tornio Town.

The Struve Geodetic Arc station TORNEA (present spelling Tornio) is documented as authentic in geographical position, design and setting. The measurements from and to this station were made using the tower of the "Nieder-Tornea" Church called now the Alatornio Church. (Alatornion kirkko). This church is the third one on that site. The first, wooden church stood there according some documents until 1316. The oldest part of the present church was built according to one source in the 15th century, according to another in 1551. Part of that church is still left in the east side cross-arm of the present church. The building work of the Alatornio Church was started in 1794 and finished in the year 1797. According to the fashion of that time it was made in the shape of a cross–church, and C.F. Adelcrantz's new-classic Adolf Fredrik Church of Stockholm served as a pattern. The completion of the church was witnessed by a phrase printed in Swedish by hand on the outside gable of the western cross-arm saying: Enlarged under the reign of King Gustav IV Adolf in the year 1797 or "Utvidgad under Gustaf IV Adolphs regering år 1797"

Alatornio church.
(Appendix III: **Photo No 17.**)

The tower of the church has been unchanged since that time. Only repainting and smaller reparation works have been carried out, but the construction itself is original. So the Struve Geodetic Arc station is today in the same, authentic place and construction as it was in the time of Arc measurements in the years 1842 and 1851. The engravings from those years can be found still on the inside walls of the tower-rooms. The top of its tower rises some 40 metres above the sea level. This high peak was a natural place to make triangulation observation during the arc measuring.

Since the Arc measurement the tower of the church has been used also as a triangulation tower. In 20th century National Land Survey of Finland used the tower for that purpose and nowadays in the tower is the triangulation point of Tornio town.

For the work on the Arc sights from far away would have been made to the top point of the tower and observations from the church made at that part of the tower open on each side. These separate positions would be inter-related (see Appendix I, p. 4 for details of offset or satellite points). Note that Maupertuis did not use this tower but the other one in Tornio town.

The Church of Alatornio is conserved by the Finnish Church Act.

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12. **PUOLAKKA** (Finland)

Established.	1834.
Type of mark.	Drill hole in bedrock.
Condition.	In good condition.
Status.	Points of national survey close to the Arc site.

The point of the Struve Arc PUOLAKKA has the drill hole surviving; its authenticity is based on its permanent use and confirmed by direct measurements related to the adjacent triangulation point. No major changes have been made in the vicinity of the station. The surrounding area used to make observation and measurements is an open space on the rocky hill as it was at the time of the Arc measurements. Today trees are obstructing some sight lines to the neighbouring points.

41. PUOLAKKA. $h = 99$ TOISES.

C'est le nom d'un village appartenant à la chapelle de KORPILAKS, paroisse de JÄMSÄ. Le rocher ORAVA-VUORI, est à 2 verstes au S de ce village, et s'élève rapidement des bords du lac PÄJÄNE. La station est sur ce rocher, et le point est marqué par un trou dans le roc.

Figure 2.
The description of Struve Geodetic Arc station PUOLAKKA; Struve F.G.W. *Arc du méridien de 25º 20' entre le Danube et la Mer Glaciale mésure depuis 1816 jusqu'en 1855.* Tome second. St Petersburg, 1857.

Now there is a surviving memorial place and information board situated on the top of the rocky hill called Oravivuori. Since the Arc was measured, the station PUOLAKKA has been a fundamental geodetic point for Finnish national mapping activities, thus keeping its identity. The Geodetic Institute measured on the same spot a first order triangulation point in 1930. This new point is at a distance of 0,43 m from the Arc point. The National Land Survey of Finland had its triangulation tower on the hill for several decades before triangulation with GPS came in use mid 1980s. To commemorate the conventional methods for triangulation the National Land Survey of Finland and the Geodetic Institute built in 1998 a wooden triangulation tower on the top of hill. It stays on the centre of the point of the National Land Surveys triangulation station. On the same hill was situated from 1969 to 1987 a station of the astronomical triangulation of the Finnish Geodetic Institute. To the station runs a marked path from the public way. On the spot has been placed an information board relating the history of the Arc and also detailing modern methods for triangulation and mapping.

The site is conserved by the Ancient Monuments Act.

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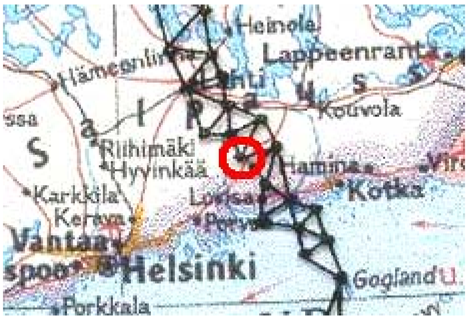
13. PORLOM II (Finland)



Established.	1833.
Type of mark.	Drill hole in bedrock.
Condition.	In good condition.
Status.	Fundamental point in national survey is located close to the Arc site.

The point of the Struve Arc PORLOM II has authenticity based on its permanent use and confirmed by direct measurements related to the adjacent triangulation centre point. No major changes have been made in the vicinity of the station. The setting undoubtedly corresponds to the original description. The surrounding area used and needed to make observation and measurements is as it was at the time of the Arc measurements. Nowadays the thickened forest will obscure the sightlines to the neighbouring sites.

25. STURE—PORLOM = PORLOM II. h = 50 TOISES.

Ce signal est placé au dessus de la pente méridionale du même rocher KOSENKUUN-KALLIO, et est également marqué par un trou foré dans le roc. La distance des deux signaux PORLOM I et PORLOM II n'est que de 246,1 toises.

Figure 3.

The description of Struve's Geodetic Arc station PORLOM II; Struve F.G.W. *Arc du méridien de 25º 20' entre le Danube et la Mer Glaciale mésure depuis 1816 jusqu'en 1855.* Tome second. St Petersburg, 1857.

Since the Arc was measured, the station has been a fundamental geodetic point for Finnish national mapping activities, thus keeping its identity. The Geodetic Institute measured near the same spot a first order triangulation point in the year 1922. This new point is at a distance of 64,49 m from the Arc point. Later on the National Land Survey of Finland had its triangulation tower on the hill for several decades before GPS came in use late 1980s.

The centre point and the witness marks of the measurement of the Geodetic Institute exists as well as the point of the Struve Arc. A path runs to the station from the public way and the place itself is very popular for local people to look at the surrounding landscape.

The site is conserved by the Ancient Monuments Act.

14. SVARTVIRA (Finland)

Established. 1833.
Type of mark. Drill hole in bedrock.
Condition. In good condition.
Status. Fundamental point in national survey is located close to the Arc site.

The Struve Geodetic Arc station SVARTVIRA (the Finnish name at the present time is Mustaviiri) has its authenticity based on its permanent use and confirmed by direct measurements related to the adjacent triangulation centre point. No major changes have been made in the vicinity of the station. The setting undoubtedly corresponds to the original description. The surrounding area used to make observation and measurements is as it was at the time of the Arc measurements. Nowadays the forest will obscure the sightlines to the neighbouring sites.

The island Mustaviiri or Svartvira (Swedish name) is situated in the Gulf of Finland some 30 km south from City Kotka. It is on a flat area of bedrock surrounded by the typical Finnish archipelago forest.

Since the Arc was measured, the station SVARTVIRA has been a fundamental geodetic point for Finnish national mapping activities. A first order triangulation point was measured near the same spot in 1930. This new point is at a distance of 9,33 m from the Arc point. The whole island on which the site is situated belongs to the National Park of “Itäinen Suomenlahti”. The National park is open for all to visit. A path runs from the harbour to the survey station.

The site is conserved by the Ancient Monuments Act.

15. MÄKI-PÄÄLYS *(Read in conjunction with 16)*

Established. 1826.
Type of mark. Iron mark in bedrock.
Condition. Now has a 1,5 m high marker and plaque installed in 2000.
Status. Geodetic point in national survey.

The property MÄKI-PÄÄLYS is a geodetic station marked with a permanent stand of metal. Its core area extends to one metre off the limits of the stand. It is situated on a small (20-25 m) rocky ground on the top of the hill Mäkipäällys (present-day spelling) on the island of Gogland (present-day spelling for Hogland). It is situated in the vicinity of the island’s only harbor Suurkülä. A 1,2 km long path runs up the hill from the harbour.

The height of the ground is 143 m above sea. Exactly above the centre a 1,5 m high stand of iron was installed in bedrock in August 2000. Its function is to support present-day technological units - especially satellite ones - aimed at surveying and mapping. Around the original hole containing the pivot are four other shallow holes made symmetrically at distances c.12 cm, as well as an inscription “1825/93” on rock 40 cm west of the Struve pivot. A memorial plaque attached to the stand describes the role of this station.

The station MÄKI-PÄÄLYS meets the test of authenticity as follows. The exact geographical position was marked by Struve with a pivot of iron placed into rock. The pivot survives, it is 10 lines of Paris (23 mm) in diameter; its identity was proved by comparison with Struve's description, as well as by special measurements carried out in 1994 and 2000. Design, material of the mark and the setting undoubtedly correspond to the description by Struve. The Struve mark suffers some deterioration of its integrity regarding the loss of the original plug of lead (some remnants can still be seen). Original visibility from the station to the adjacent stations on either shore of the Gulf of Finland is obscured by growing trees.

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16. HOGLAND, POINT Z (Russia) *(Read in conjunction with 15)*

Established.	1826.
Type of mark.	Permanent mark established over location in 2000 with plaque.
Condition	In good condition.
Status.	Under formal procedure to become a new geodetic point in national survey

Both inter-related properties, MÄKI-PÄÄLYS and HOGLAND, Z, are situated on the island of Hogland in the Gulf of Finland, the municipality of Kingisepp, Leningrad Region, about 180 km west of St. Petersburg. Ship or helicopter trip is necessary to visit the sites. Both properties are important positions in the Struve Geodetic Arc as they:

- exhibit the unique Struve solution of the problem of trigonometrically crossing the wide sea space with only one point linking two separated chains on the continental areas;
- are directly associated with the name of Struve, who initiated and personally participated in measurements and was permanent leader of the arc measurement until its full completion;
- exhibit a unique type of the Arc station with far separated trigonometric and astronomical observing sites thus requiring an additional linkage operation;
- safeguard one of the Arc principal astronomical stations observed by Struve himself (the other is the station Jacobstadt, no. 21); the astronomical ground bears tangible evidence, due to its setting, of Bessel's method of latitude determination with the help of observations in the prime vertical; the method was applied here by Struve and his associates (it has long disappeared from practice);
- exhibit the only surviving identical mark put by Struve and the remnants of physical material used for the establishment of the famous telescope by Dollond (prominent English instrument maker, his telescope is surviving in Struve's observatory in Estonia).

A wiev of the Arc site HOGLAND, Z.
(Appendix III: **Photo No 29.**)

The property HOGLAND, POINT Z is a geodetic station marked with a monument of stones. Its core area extends to one metre off the limits of the stonework. It is situated on a small (10 m by 5 m) horizontal rocky ground at the foot of a hill situated 700 m west of the harbour Suurküla. The vertical wall of the hill presents a surviving feature described by Struve. A sandy village road runs by the site to the Upper Lighthouse. The height of the ground is 30 m above sea level.

The surveyed position of the arc point has been marked by a monument made of natural stones and concrete in August 2000. Its function is to indicate the exact place of the astronomical observation made here by Struve in 1826. An attached memorial plaque describes the role of this station. The station HOGLAND, POINT Z meets the test of authenticity as follows. Its geographical position, though not marked with a material sign, was precisely interrelated with the position of MÄKI-PÄÄLYS within the same survey Struve made in 1826.

The position was surveyed and monumented with the help of special measurements carried out in 1994 and 2000 on the basis of the complete information set out in Struve’s account. The setting and the very small astronomical ground undoubtedly correspond to the description by Struve. Physical remnants of two substantial pillars of brick which supported Struve’s telescope in 1826 can also be seen on the ground. The property meets the requirement specified in Operational Guidelines, paragraph 24 (b) (i), regarding acceptability of reconstructions.

The island of Gogland in the Gulf of Finland was chosen by Struve and Walbeck in 1821 with the aim to extend to Finland the arc measurement proposed in the Russian Baltic provinces. This linking function of the island was established during 1826 - 1843. Objective reasons made Struve choose several observing sites on the island during his 1826 expedition. The trigonometric and latitude observations have been separated both by distance (1,4 km) and height (113 m), therefore two different memorial sites are proposed. The exact interrelation between their geographical positions resulted from Struve’s ancillary survey.

Due to precise trigonometric and astronomical linkage of the two separated parts of the measurement across the Gulf of Finland MÄKI-PÄÄLYS has become an important station for surveying and mapping activities in the region. Its centre point, i.e. Struve’s pivot of 1826 has been used in building regional co-ordinate networks (Russian surveys of 1826-1833, 1893 and 1953-1957, national Finnish surveys of 1917-1940). The station is still part of the present-day national Russian co-ordinate network. It is one of the oldest European geodetic stations.

HOGLAND, POINT Z was used by Struve in the final table of geodetic results of the Arc measurement, instead of the station MÄKI-PÄÄLYS. Since then Struve’s astronomical ground has not been used again, even during the new astronomic observations performed in 1833 for the international Baltic longitude expedition. No information has so far been found about later history of the site. Two special missions investigated and surveyed the place, first in 1994 and another survey was made in 2000. In August 2000 a memorial construction was built on the surveyed position, using salvaged pieces of bricks and lime in the facing. A new astronomic observation of the latitude of the position gave good agreement. A formal procedure will result in including the station HOGLAND, POINT Z into the national co-ordinate network.

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17. WOIBIFER (Estonia) *(Read in conjunction with 18)*

Established.	1827.
Type of mark.	Drill hole in granite block uncovered in 2000.
Condition.	In good condition.
Status.	End of baseline. Not in modern use

18. **KATKO** (Estonia) *(Read in conjunction with 17)*

Established.	1827.
Type of mark.	Iron bar in granite blocks. Now has granite monument.
Condition.	In good condition.
Status.	End of baseline. Not in modern use.

The geographical position of the Struve Geodetic Arc stations WOIBIFER (Võivere) and KATKO (Simuna) were proved by special work carried out in 2000 by Estonian Land Board. Both inter-related properties are situated in the village Võivere and municipality of Avanduse, the county of Lääne-Viru. These properties exhibit also a very important object of the Struve Geodetic Arc; they are the end points of the Simonis baseline (see Appendix I, p. 4 for explanation of baseline). The baseline is a key element of triangulation. It is a relative short line to be measured as accurately as possible. By starting from the measured baseline the longer distance has been calculated using extension points and observed angles of triangles.

The baseline´s southeast terminal station KATKO (Simuna) was marked some long time back with a 1,90 m high granite monument. The monument consists of four parts. The lowest part is 204×204 cm^2 limestone foundation. On the foundation there is a granite stone block 64×64×32 cm^3. The third part is also a granite block 64×64×38 cm^3 with a 10 cm iron bar in the centre for attaching the upper part - a 1,20 m high pillar. The year of establishment 1849 is engraved in the monument.

Until recently the baseline's northwest terminal station WOIBIFER (Võivere) had been considered destroyed. As a result of instrumental search the marker of this point was found buried. The monument consists of a limestone foundation of 204×204 cm on which there is a large round granite stone with a drill hole for marker.

To check the locations of the end stations, their coordinates were determined with GPS and the length of line between the markers was calculated. The difference between theoretical and measured distances of 13 mm shows that these are correct points, i.e. those used by Struve.

The baseline was situated in the plain fields of Avanduse and Võivere estates, where the relief did not impede the measurements. The height difference between the end points of the baseline was 6,3 m and the length of baseline 4,5 km. Both positions are registered sites in the National Heritage Register of Estonia.

19. **DORPAT** (Estonia)

Established.	1816-19.
Type of mark.	Bolt in floor of Observatory.
Condition.	Well maintained. Descriptive plate added 2002.
Status.	Datum point of Struve observations.

The Struve Geodetic Arc station DORPAT (present name Tartu) Observatory is situated in the county of Tartu, in the city of Tartu. The property is a very important object of the Struve Geodetic Arc thus it is one of the few actual buildings in the Struve Arc. The Tartu Observatory was built in 1810, but after the arrival of the Fraunhofer refractor in 1824 it was noted that the cupola of the observatory was made too small for the new telescope. Under supervision of the director of the Tartu University, G.F.Parrot a new cupola was built in 1825. The history of the Dorpat Observatory can be described brief as follows.

1802	Reopening of the Tartu University
1805 - 07	The first temporary observatory at the junction of Poe / Küüni streets, founded by the Professor of mathematics Johann Pfaff.
1807 - 09	The second temporary observatory in the house of amateur astronomer Andreas von Lamberti on Õpetaja Street.
1808	Started building works for the observatory to the SE part of the hill of Toome on the ancient ruins of castle.
1810	The new observatory was completed
1813	W. Struve was named as astronom-observator to the montage works of the Dollond passaaz instrument.
1814	Regular observations began in the Tartu Observatory.
1820 - 39	W. Struve was appointed the director of the Tartu Observatory.
1822	The Reichenbach meridian circle arrived.
1824	The Fraunhofer refractor arrived. It was with its 9-inch diameter lens the biggest and best lens telescope in the world.
1825	Reconstruction works. The cupola of the observatory was enlarged after the Fraunhofer refractor was installed. W. Struve was using it mostly for studying double stars.
1837	The important work of W. Struve “Stellarum dupliciumet multiplicium mensurae micrometricae” was published, where together with results of his works on double-stars, was represented his determination of the distance of two stars- the first time in the world.
1839	W. Struve left Tartu to become director of the Pulkovo Observatory (near St. Petersburg).
1840 - 64	The new director of the Tartu Observatory J.H.Mädler found fame as researcher of the Moon. His book “Wunderbau des Weltalls, oder populäre Astronomie” was published in many editions.
1897	In the side of the hill Toomemäe was built a small observatory and in the same year a Repsold Zenith Telescopewas installed.
1911	The Fraunhofer refractor in the tower of the Tartu observatory was replaced with a new 8-inch Zeiss refractor.
1919 - 48	The first Estonian director in the observatory- Taavet Roosmäe.
1946	Observatory belongs to the Academy of Sciences. The rooms of observatory were also used for work in physics.
1964	Astronomers moved to the newly opened observatory in Tõravere (near Tartu). The only astronomer who stayed was Hugo Raudsaar who continued his observations on asteroids and comets.
1971	The Observatory Museum was opened.
1975	The last scientist moved away and the Tartu Observatory began a silent period.
1996	The Observatory again came under the control of the Tartu University.

Tartu Observatory, the site of Struve Arc DORPAT.
(Appendix III: **Photo No 38.**)

It is directly associated with the name of Struve, who initiated, personally participated in measurements and was permanent leader of the measurement until its full completion. The test of authenticity regarding its geographical position was proved by the recent special works carried out in 2000 by the Estonian Land Board. The centre point in Dorpat (Tartu) Observatory had not been preserved and was restored and monumented in 2002 with a 12 mm bronze marker and surrounding inscription bedded in the floor. The centre location was measured and checked with GPS. This point served as the origin for all Struve's observations relating to the Arc.

To quote from the first volume of Struve's *Arc du méridien de 25° 20' entre le Danube et la Mer Glaciale mésure depuis 1816 jusqu'en 1855*, page II: "La distance entre les dits points extrêmes, comptée sur le grand cercle qui les joint, est de 2700 verstes = 2880 kilomètres = 388 milles géographiques. L'Observatoire de DORPAT se trouve à peu près à mi-chemin de cette ligne, étant éloigné de 1300 verstes = 1387 kilométres = 187 milles géographiques de FUGLENAES et de 1400 verstes = 1493 kilométres = 201 milles géographiques de STARO-NEKRASSOWKA, et subdivise l'arc du méridien total en deux portions presque égales; ..... Par conséquent le méridien de DORPAT doit être regardê comme le méridien principal de notre arc total, et l'OBSERVATOIRE de DORPAT est en même temps le point fondamental de cet arc, ..."

Next to the Observatory is the house in which Struve lived while he was at the Observatory. There are hopes that this also can be preserved at a later date.

The site is registered in the National Heritage Register of Estonia.

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20. **SESTU-KALNS** (Latvia)

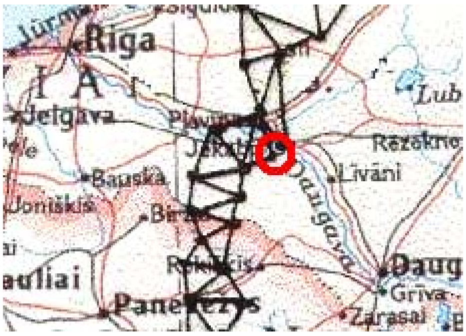
Established.	1824.
Type of mark.	Drill hole in rock.
Condition.	Good condition.
Status.	Fundamental point in national survey.

The point of the Struve Arc SESTU-KALNS was originally marked in 1824 and fixed with an underground centre in 1828 by I.I.Hodzko (И.И.Ходзько), who carried out angular observations in the measurement of the Baltic and Lithuania triangulation. The station SESTU-KALNS is located on the top of the hill 216,5 m above sea level. The hill nowadays called Ziestu is in the private property "Kalna Vēņēni". Since the Arc was measured, the station SESTU-KALNS has been a fundamental geodetic point for Latvian national mapping and surveying activities, thus keeping its identity.

In 1904 captain Emeljanov (Емельянов) renovated this centre. During 1903 - 1904 he set a new first order triangulation chain of meridional measurements from stations Munamagi (Мунамяги) and Esamagi (Есамяги) in Estonia to the side of the arc measurement Gaisakalns – Kreutzburg. On the recommendation of F.N. Krasovskij the astronomical position and azimuth were determined on three stations Gaisakalns, SESTU-KALNS and Jacobstadt during the first order triangulation works in Latvia 1922 – 1940. Nowadays this station is used as a first order state reference network point named Sestukalns.

When research was carried out in 2002 the bedrock with a cross in the middle and mark of 1904 was found. No substantial change has been detected in the state of physical conservation of the property.

21. JACOBSTADT (Latvia)



Established.	1826.
Type of mark.	Pillar with central iron mark, renovated by granite block in 1931.
Condition.	Good condition.
Status.	Fundamental point of national survey.

Struve chose the Arc station JACOBSTADT as the Southern endpoint of his measurements. The point of the Struve Arc was marked in 1826 with a 4-foot high pillar dug into the ground. The iron bar was bedded in the pillar and its centre matched with the vertical axis of the instrument. The construction was damaged and in 1931 a new granite block was bedded on top of the old one. The station Jacobstadt is located in the Struve Park in the historical centre of Jēkabpils (town) next to Struve Street that leads to Struve Park. The park is approximately 1,2 ha large.

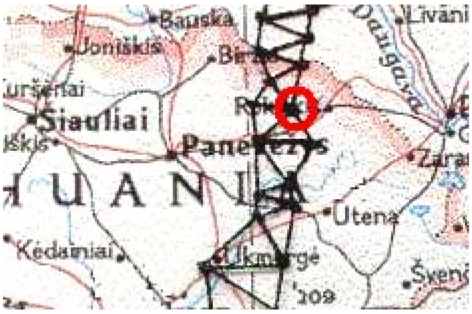
Since the Struve Geodetic Arc was measured, the station JACOBSTADT has been a fundamental geodetic point for Latvian national mapping and geodetic activities, thus keeping its identity. This station was measured as a first order Latvian triangulation point in the years 1922 - 1940. The Struve Park was established to honour the great work and contribution F.G.W. Struve made in research of the shape and size of the earth. In June 2002 the memorial plaque (see illustration below) was established.

The sign commemorating the station JACOBSTADT.
(Appendix III: **Photo No 44.**)

The geodetic point JACOBSTADT is of considerable importance. Not only is it a triangulation point of the Struve Arc but it is also an astronomical station, is the southern end point of the Struve's own personal measurements and through the triangle side Daborkalns - Jacobstadt a connection was made between Struve's arc and Tenner's arc This is the place where the real problems appeared in the process of connecting the two arcs because two different kinds of unit of length had been used: the Russian-English sajene (7-feet Tenner´s standard) and the Russian-Frenc toise (6-feet Struve´s standard). This connection was h carried out under the supervision of the celebrated scientist Bessel who confirmed that the connection was accurate.

Since the granite block was bedded on top of the old one in 1931 no substantial change has been detected in the state of physical conservation of the property.

22. KARISCHKI (Lithuania)



Established. 1816-21.
Type of mark. Wooden log, remonumented in 1920s.
Condition. Good condition.
Status. Second order point of national survey.

The Struve Geodetic Arc station KARISCHKI (present spelling Gireišiai) was monumented with a wooden log. Polish surveyors re-monumented the point in 1925-30 with concrete blocks. No major changes have been made in the vicinity of the station. The station was a point of the First order triangulation network of the Vilnius province designed by C. Tenner, consisting of 119 triangles, connecting 98 points. Average length of triangle sides was 25 km. Angles and baselines were measured in 1816–1821. Later in 1822–1829 the network was extended to Kurland province – Latvian territory today. The surrounding area used to make observation and measurements is an open space as it was at the time of the Arc measurements.

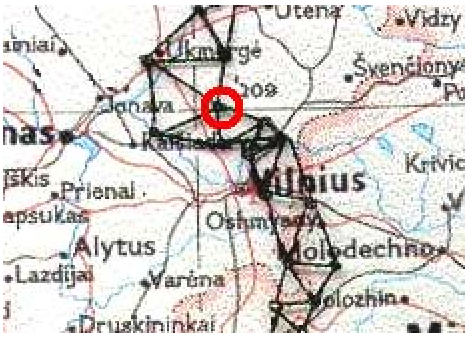
Since the Arc was measured, the station KARISCHKI has been a fundamental geodetic point for Lithuanian national mapping activities. In the period between WWI and WWII the point was part of the Triangulation network of independent Lithuania. That network consisted of 86 points and was established between 1927–1939 by the Military Topographic Department of Defence Ministry of Lithuania.

Connection of the Lithuanian, Polish and Latvian triangulation networks was started by the Soviet Army Military Topographic Service in 1940 in Kapčiamiestis area. Observations were continued after WWII between Zarasai and Rokiškis and between Širvintos and Paberžė. After the break, in 1967 the Soviet military connected the Lithuanian, Polish and Kaliningrad area pre-war triangulation networks in the Lazdijai – Kybartai – Smalininkai area. The connected triangulation networks were adjusted and the resulting coordinates computed in a Co-ordinate system of 1942 that remained the geodetic reference until the end of Soviet period. The station KARISCHKI was a point in the State first order triangulation network.

The Lithuanian National GPS Network was established in 1992-1998 and has replaced the national triangulation used for 170 years. The network was based on GPS points observed during international program EUREF BAL92. The station KARISCHKI is a point in the State second order GPS network.

The Arc station KARISCHKI.
(Appendix III: **Photo No 46.**)

23. MESCHKANZI (Lithuania)



Established.	1816-21.
Type of mark.	Natural stones and lime safeguarding The marked central stone, remonumented in 1930s.
Condition.	Good condition, renovated in 1992.
Status.	Zero order point of national survey.

The Struve Geodetic Arc station MESCHKANZI (present spelling Meškonys) was monumented from local stones bonded together and set in a pit. Polish surveyors re-monumented the point in the 1930s with concrete blocks. The monument of the station was renovated in 1992 by establishing the new modern monument (type G-04). No major changes have been made in the vicinity of the station. The station was a point of the First order triangulation network of the Vilnius province designed by C. Tenner, consisting of 119 triangles, connecting 98 points. Average length of triangle sides was 25 km. Angles and baselines were measured in 1816–1821. Later in 1822–1829 the network was extended to Kurland province – Latvian territory nowadays. The surrounding area used to make observation and measurements is an open space as it was at the time of the Arc measurements.

Since the Arc was measured, the station MESCHKANZI has been a fundamental geodetic point for Lithuanian national mapping activities. In the period between WWI and WWII the point was part of the First order triangulation network of Vilnius area occupied by Poland. That network was established between 1925–1939 by the Military Geographic Institute and Public Works Ministry of Poland.

Connection of the Lithuanian, Polish and Latvian triangulation networks was started by the Soviet Army Military Topographic Service in 1940 in Kapčiamiestis area. Observations were continued after WWII between Zarasai and Rokiškis and between Širvintos and Paberžė. After the break, in 1967 the Soviet military connected the Lithuanian, Polish and Kaliningrad area pre-war triangulation networks in the Lazdijai – Kybartai – Smalininkai area. The connected triangulation networks were adjusted and the resulting coordinates computed in the system CS-42 that remained the geodetic reference until the end of Soviet period. The station Meškonys was a point in the State first order triangulation network.

This point is surrounded by a 0,5 m high openwork profile reinforced concrete fence. The outer side the fence carries an information plaque. The position is conserved by the Law on Protection of Immovable Cultural Properties.

24. BERESNÄKI (Lithuania)

Established.	1816-21.
Type of mark.	Natural stones and lime safeguarding the marked central stone, remonumented in 1920s.
Condition.	Good condition, renovated in 1992.
Status.	Second order point of national survey.

The Struve Geodetic Arc station BERESNÄKI (present spelling Paliepiukai) was monumented from local stones bonded together and set in a pit. Polish surveyors re-monumented the point in 1925-30 with concrete blocks. The monument of the station was renovated in 1992 by establishing the new modern monument in connection of the European GPS-campaign of EUREF89 BAL92. No major changes have been made in the vicinity of the station. The station was a point of the First order triangulation network of the Vilnius province designed by C. Tenner, consisting of 119 triangles, connecting 98 points. Average length of triangle sides was 25 km. Angles and baselines were measured in 1816–1821. Later in 1822–1829 the network was extended to Kurland province – Latvian territory today. The surrounding area used to make observation and measurements is an open space as it was at the time of the Arc measurements.

Since the Arc was measured, the station BERESNÄKI has been a fundamental geodetic point for Lithuanian national mapping activities. In the period between WWI and WWII the point was part of the First order triangulation network of Vilnius area occupied by Poland. That network was established between 1925–1939 by the Military Geographic Institute and Public Works Ministry of Poland.

Connection of the Lithuanian, Polish and Latvian triangulation networks was started by the Soviet Army Military Topographic Service in 1940 in Kapčiamiestis area. Observations were continued after WWII between Zarasai and Rokiškis and between Širvintos and Paberžė. After the break, in 1967 the Soviet military connected the Lithuanian, Polish and Kaliningrad area pre-war triangulation networks in the Lazdijai – Kybartai – Smalininkai area. The connected triangulation networks were adjusted and the resulting coordinates computed in a Lithuanian system of 1942 that remained the geodetic reference until the end of Soviet period. The station BERESNÄKI was a point in the State first order triangulation network.

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25. **TUPISCHKI** (Belarus) *(Read in conjunction with 26-29)*

Established. 1827.
Type of marks. Brick concealed in the stone foundation.
Condition. Good condition.
Status. Part of national geodetic survey.

The geographical positions of the Struve Geodetic Arc stations TUPISCHKI, LOPATI, OSSOWNITZA, TCHEKUTSK and LESKOWITSCHI were proved by the recent special works carried out in 2002. These were obtained as a result of satellite measurements in the coordinate system of the Republic of Belarus and calculated with the help of measurement values taken from the published work of Struve *Arc du méridien de 25º 20' entre le Danube et la Mer Glaciale mésure depuis 1816 jusqu'en 1855,* and *The Catalogue of Triangulation Points of the 1st grade*, made by the Military Topographers' Corps on the territory of European Russia and Caucuses from 1816 to 1910 and adjusted by the Commission of a military surveyor K.V.Sharngorst" (1926). As a result of recalculation into the united system the results practically coincided. The centre of the Leskovichi station had some change in comparison with its original condition. There is a hole in the middle of a granite cube left by a leaden cylinder but the cylinder itself has disappeared. Today each is surmounted by a tripod of metal pipes established above the centres of the stations. No destruction has been found in these.

The station TUPISCHKI is located in the territory of the Grodno Region of the Republic of Belarus on agricultural lands. The point is readily accessible by road.

All the stations are included in the Russian part of the Struve Geodetic Arc measured by Tenner, which was not only the longest, but the most difficult one as well. On the territory of Belarus it passed through forest and marshland and through the Pinsk Marshlands in particular, which were considered to be impenetrable. The stations are important positions in the Struve Geodetic Arc as:

- The initiator of the Lithuanian arc measurement, Tenner, directly took part in the observations.
- At the same time, Struve carried out triangulation measurements in the former Livland.
- In 1828 the measurements of Struve and Tenner were linked.

- The central points of the stations were fixed to the ground by stone foundations and most of them have survived to the present day.

To provide visibility between stations tall wooden signals were built. In spite of which the quality of measurements is not inferior to works that were performed 30 years later by Bessel.

In 1815 Tenner was charged with the assignment to establish triangulation in the province of Vilna, and later in Curland, Grodno and Minsk provinces of Russia. In the process of carrying out his works in the province of Vilna he started triangulation measurements on his own initiative along the meridian of Vilna astronomic observatory, which was prolonged, to the south. According to his suggestion these measurements were linked to those of Struve. Under the leadership of Tenner the southern part of the Arc was measured between the Danube and the Dvina. The Struve Arc stations located on the territory of Belarus, including Tupischki and Lopati, Ossownitza, Tchekutsk and Leskowitschi were part of provincial triangulations of Russia and later they were included into the geodetic system of the USSR and the Republic of Belarus.

The centre of TUPISCHKI point is represented by a brick concealed vertically in the foundation of wild stone and fixed with lime.

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26. **LOPATI** (Belarus)

Established. 1827.
Type of marks. Brick concealed in the stone foundation.
Condition. Good condition.
Status. Part of national geodetic survey.

The centre of LOPATI point is represented by the foundation of wild stone in the centre of which a brick with a pierced hole is placed. Above the brick a wooden pole is erected, which is also surrounded by stones.

The station LOPATI is located in the territory of the Grodno Region in agricultural lands. The point is readily accessible by road.

The hole of the centre pole, LOPATI.
(Appendix III: **Photo No 52.**)

27. OSSOWNITZA (Belarus) *(Read in conjunction with 28)*

Established. 1827.
Type of marks. Sandstone with diagonals drawn on it.
Condition. Good condition.
Status. Part of national geodetic survey.

The centre of OSSOWNITZA point is similar to the centre of Leskovichi point; the only difference is that instead of the granite cube was established a sandstone cube with diagonals drawn on its upper surface.

The stations OSSOWNITZA and TCHEKUTSK are situated at the NE and SW ends respectively of Ossownitza base line. The baseline is a key element of triangulation. It is a relative short line to be measured as accurately as possible. By starting from the measured baseline the longer distance has been calculated using observed angles of triangles (see Appendix I, p. 4 for details of baseline).

The length of the baseline Ossownitza measured with GPS in 2001 is 11 148,256 m, which differs by 3,5 cm from the measurement performed by Tenner in 1827.

The stations OSSOWNITZA and TCHEKUTSK are located in the Brest Region of the Republic of Belarus on agricultural lands. The points are readily accessible by road.

28. TCHEKUTSK (Belarus) *(Read in conjunction with 27)*

Established. 1827.
Type of marks. Granite stone with drill hole.
Condition. Good condition.
Status. Part of national geodetic survey.

The centre of TCHEKUTSK point is represented by the foundation of wild stone, fixed with lime and in the centre of which a granite cube is placed (see Leskowitchi below). The position of the cube is marked with five bricks put on the top. A hole was pierced in the centre of the central brick. TCHEKUTSK is the SW end of Ossownitza baseline.

29. LESKOWITSCHI (Belarus)

Established. 1827.
Type of marks. Granite stone with drill hole.
Condition. Good condition.
Status. Part of national geodetic survey.

The centre of LESKOWITSCHI point is represented by a granite cube (the side is 25,4 cm) with the cylindrical hole inside filled with lead. It is put into the foundation of wild stone and fixed with lime. The centre of LESKOWITSCHI point has undergone some changes in comparison with its original condition. There is a hole in the centre of the granite cube left by a leaden cylinder. The cylinder itself has disappeared.

LESKOWITSCHI station was also used while creating the baseline of Ossownitsa and in 1833 it was used in laying of new triangulation line in Minsk province.

The station LESKOWITSCHI is located in the Brest Region of the Republic of Belarus on agricultural lands. The points are readily accessible by road.

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30. RUDY (Moldova)

Established. 1847.
Type of mark. Drill hole in sunken pillar.
Condition. Good condition.
Status. Not in modern use

The point RUDY of the Struve Geodetic Arc is represented by a brick pillar, 40 cm x 40 cm sunk into a 1m deep pit located in a mound of diameter 2,5m, height approx. 50 cm. Basement thickness is one brick. The point is accessible to motor transport (approx. 300 m from motorway Soroca –Otaci).

The RUDY point was established and monitored during September - October 1847, with check measures to horizontal and vertical corners on adjoining points.

The point and site are conserved under the Act for Ancient Monuments.

The centre block of RUDY.
(Appendix III: **Photo No 52.**)

31. KATERINOWKA (Ukraine)

Established. 1835-40.
Type of mark. Cross on iron embedded in brickwork.
Condition. Now specially marked in 2003.
Status. Point in State survey.

The point KATERINOWKA of the Struve Geodetic Arc was marked by Tenner with a cross carved on brickwork during the triangulation in Podolsk Province in 1835-1840. In 1928-1932 an iron mark was embedded in brickwork by the Military Topographic Service of Red Army during 1st order astrogeodetic network. At same time two ferro-concrete pylons were inserted into the brickwork, their vertical axis was exactly centred to the point installed by Tenner.

The original visibility from the site to others is lost. But due to GPS observation the value of the Katerinowka-Felschtin baseline was obtained. The computed value of this baseline conforms with the same made by Tenner and indicates authenticity of Katerinowka site.

The property is situated on a mound 1,0 km north from Katerynivka village, which is in Khmelnytskiy district, Khmelnytskiy region, and 25 km northwest from Khmelnytskiy city. The station is in the municipality of Antonivka village council. It is possible to get to the location by car. The Arc point Katerinowka is situated on a mound 0,7 km from road, which connects villages Katerynivka and Savchintsi. Its height is 345 m above sea level.

Coordinates of sites on the Struve Geodetic Arc in Ukraine were calculated in WGS-84 and CS-42 coordinate systems at the preparatory stage. From the obtained coordinates of the centre of Katerinowka station was found. It is a site of the State Geodetic Network of Ukraine, consistent with the position of the Struve Geodetic Arc site Katerinowka. Inspection work was performed on the site in 2003, as well as the GPS survey. Results of the GPS observations gave a good conformity with the results of observations made by Tenner to confirm the authenticity of Katerinowka site. In 2003 a memorial monument was placed in front of the property with words of explanation of the role of this station. At the same time as the reconstruction work was performed – an area around the site was dug in triangular form.

Since reconstruction in 2003 no substantial damage has been detected in the state of physical conservation of the property.

32. FELSCHTIN (Ukraine)

Established. 1835-40.
Type of mark. Iron mark in rock.
Condition. Now specially marked in 2003.
In good condition.
Status. Point in State geodetic network.

The property FELSCHTIN of the Struve Geodetic Arc is situated 0,6 km southwest from the Hvardiiske village, which is in Khmelnytskiy district, Khmelnytskiy region, and 20 km southwest from Khmelnytskiy city. Hvardiiske village council is the owner of the land on which the property is situated. It is possible to get to the point by car. The point is situated on a mound 0,1 km from road, which connects villages Hvardiiske and Khmelivka. Its height is 354 m above sea.

The station is marked by rock, in which Military Topographic Service of Red Army installed an iron mark in 1935 during 1st order astrogeodetic network. The original visibility from the site to others is lost, but from GPS observations the Felschtin-BARANOWKA triangle side was found. The computed value of this line conforms with that made by Tenner and indicates authenticity of the Felschtin site. In 1961 a ferroconcrete pylon was inserted into the rock by the Military Topographic Service of Red Army. In 2003 a memorial monument was placed in front of the property with words of explanation of the role of this station.

The Arc Site FELSCHTIN.
(Appendix III: **Photo No 60.)**

First observation on Felschtin site was performed in 1835-1840 by Tenner during triangulation network creation in Podolsk province. Four hours of GPS observation were performed on the Felschtin site in May 2003 within the framework realization of “Struve Geodetic Arc sites reconstruction” project. At the same time reconstruction work was performed and an area around the site was dug in triangular form.

The position of the centre of Felschtin station, which is one of sites of the State Geodetic Network of Ukraine, is consistent with the position of the Struve Geodetic Arc site Felschtin. Inspection work has been performed on the site in 2003 as well as a GPS survey. Results of the GPS observation have a good conformity with results of observations made by Tenner to confirm the authenticity of the Felschtin site.

Since reconstruction in 2003 no substantial change has been detected in the state of physical conservation of the property.

33. BARANOWKA (Ukraine)

Established.	1835-40.
Type of mark.	Iron mark in rock, remonumented in 1935 and renovated in 1961.
Condition.	Now has memorial monument and explanation. In good condition.
Status.	Point in the State geodetic system.

The property BARANOWKA is situated west from the Baranivka village, which is in Yarmolyntsi district, Melnytskiy region. Baranivka village inhabitant Ludmila I. Zhuk is owner of the land on which the property is situated. Its location is about 25 km south from Khmelnytskiy city and 10 km southeast from Yarmolyntsi town. It is possible to get to the place by car.

The point Baranowka of the Struve Geodetic Arc is situated on a mound 0,4 km from road, which connects villages Baranivka and Sutkivtsi. Its height is 332 m above sea level. The station is marked by rock, in which the Military Topographic Service of Red Army installed an iron mark in 1935 during observation of the 1st order astrogeodetic network. In 1961 a mound was made on Baranowka and in addition a ferroconcrete pylon was inserted into the rock by the Military Topographic Service. In 2003 a memorial plaque was placed in front of property with the words of explanation of the role of this station.

The first observation on the Baranowka site was performed in 1835-1840 by Tenner during his triangulation network in Podolsk province. Two days of GPS observations were performed on the Baranowka site in May 2003 within the framework of "Struve Geodetic Arc sites reconstruction" project. Position of the centre of Baranowka station, which is one of sites of the State geodetic network, is consistent with position of the Struve Geodetic Arc site Baranowka. Inspection work was performed on the site in 2003. Results of GPS observations gave good conformity with results of observations made by Tenner and confirm the authenticity of Baranowka site. At the same time as reconstruction work was performed the site was dug around in triangular form.

Since reconstruction in 2003 no substantial change has been detected in the state of physical conservation of the property.

34. STARO-NEKRASSOWKA (Ukraine)

Established.	1851. Monument in 1852-55.
Type of mark.	Iron mark in rock. Now surmounted by an obelisk built in 1852-55 and renovated 1994.
Condition.	Good condition.
Status.	Point in State geodetic network.

The property is situated in the south part of the Stara Nekrasivka village on Pochtova street between houses numbered 32 and 34, in Izmail District, Odessa Region, and 5 km east from Izmail town. The station is in the municipality of Stara Nekrasivka village council. It is possible to get the place by car.

The point Staro-Nekrassowka of the Struve Geodetic Arc is situated on a mound 1 km from road, which connects village Stara Nekrasivka, and Izmail town. Its height is 20 m above sea level. The station is marked by rock, in which an iron mark was installed in 1851 by Tenner. In 1852-55 a monument was erected on Staro-Nekrassowka with its vertical axis exactly centred to the point installed by Tenner. Reconstruction and re-measure works on the setting of the site were performed on the site in October 1994. The original visibility from the site to others is lost.

First observation on Staro-Nekrassowka site was performed in 1851 by Tenner. Four days of GPS observations were performed on Staro-Nekrassowka site in October 1994 within the framework of the Russian-Ukrainian-Norwegian "Struve Geodetic Arc re-measure" project.

Coordinates of all sites on Struve Geodetic Arc in Ukraine were calculated in WGS-84 and CS-42 coordinate systems at the preparatory stage. The position of the centre of Staro-Nekrassowka station, which is one of the sites of the State Geodetic Network of Ukraine, is consistent with the position of the Struve Geodetic Arc site Staro-Nekrassowka. Inspection work was performed on the site in October 1994, as well as a GPS survey. Results of the GPS observations gave good conformity with results of observations made by Tenner and confirm the authenticity of Staro-Nekrassowka site.

Terminus australis
Arcus meridiani $25^\circ\ 20'$
quem
inde a fluvio Danubio
ad Oceanum Arcticum usque
per
Rossiam, Sueciam et Norvegiam
jussu et auspiciis
Imperatorum Augustissimorum
ALEXANDRI I
et
NICOLAI I
atque
Regis Augustissimi
OSCARIS I
annis MDCCCXVI ad MDCCCLII
continuo labore
emensi sunt
Trium gentium geometrae.
Latitudo: $45^\circ\ 20'\ 2'',8$.

Южный предѣлъ
дуги меридіана $25^\circ\ 20'$
отъ рѣки Дуная
до
Океана Ледовитаго
чрезъ
Россію, Швецію и Норвегію.
По повелѣнію
Августѣйшихъ Монарховъ
Императоровъ
АЛЕКСАНДРА I-го
НИКОЛАЯ I-го
и
Короля
ОСКАРА I-го
постоянно трудясь
съ MDCCCXVI-го по MDCCCLII-й годъ
измѣрили
Геометры трехъ народовъ.
Широта: $45^\circ\ 20'\ 2'',8$.

Figure 4.
The inscriptions on the monument of the Arc at STARO-NEKRASSOWKA; Struve F.G.W. *Arc du méridien de 25º 20' entre le Danube et la Mer Glaciale mésure depuis 1816 jusqu'en 1855.* Tome premier, St Petersburg, 1860.

The Monument of the Arc at STARO-NEKRASSOWKA, erected in 1852-55.
(Appendix III: **Photo No 66.**)

3. (c) Form and date of most recent records of property

COUNTRY	Form and date of most recent records of property
NORWAY	Records are stored by means of maps, geodetic data and archives in the official databases managed by Norwegian Mapping Authority.
SWEDEN	Property records are within the Swedish Land Register, a continuously kept database with a digital map system.
FINLAND	Records are stored by means of maps, cadastral data and information of ownership in the official databases managed by National Land Survey of Finland.
RUSSIA	1. Brief account on the inspection of the state of conservation of the two Struve Arc memorial stations on the island of Gogland. August, 19. 2003. Internal document within project 10.16.2596. “Aerogeodeziya”, St.-Petersburg. 2. Kaptjug V. et al.: Main Results of the Restoration and Research Work at the Russian Struve Station on Gogland. − Reports of the International Scientific Conference “Struve Arc – 150”, Tallinn - Tartu, Estonia, 25-27 September, 2002, p.26-34. 3. Kaptüg V. B. et al.: Restoration of the Memorial Sites of the First Russian Measurement of the Figure of the Earth on the Island of Gogland. – "Izvestiya Russkogo Geographicheskogo Obshchestva" (Proceedings of the Russian Geographical Society), 2001, v.133, 6, p.68-76 (in Russian). 4. Bill of Registration of Newfound Immovable Objects of Historical and Cultural Heritage. No 18-D, September 25, 2000 (in Russian). Government of the Leningrad Region/ Committee for Culture/Department for Preservation and Use of Memorials to the History and Culture.
ESTONIA	Records are stored by means of maps, cadastral data and information of ownership in the official databases managed by Estonian Land Board.
LATVIA	Records are stored by means of maps, cadastral data and information of ownership in the official databases managed by State Land Service of Latvia. Private property “Kalna Vēņeni” was entered in the cadastral register in 02.07.2001
LITHUANIA	Records are stored by means of maps, cadastral data and information of ownership in the official databases managed by National Land Service under the Ministry of Agriculture of Lithuania
BELARUS	Records are stored by means of maps, geodetic data and archives of the Minsk and Grodno Regions of the Republic of Belarus, Committee for Land Resources, Geodesy and Cartography of the Republic of Belarus, Department for Protection and Restoration for Historiacal and Cultural Heritage.
MOLDOVA	Records are stored by means of maps, cadastral data and information of ownership in the official databases managed by State Agency for Land Relations and Cadastre Republic of Moldova.
UKRAINE	SGA stations were included in State Geodetic Network of Soviet Union in 1930´s – 1950´s. Detail information on completed works stored in the official databases are maintained by Research Institute of Geodesy and Cartography of Ukraine.

3. (d) Present state of conservation

See section 3. (a and b).

3. (e) Policies and programmes related to the presentation and promotion of the property

According to the Resolution No. 3 of the International Conference on Struve Arc held in Minsk on October 3-5, 2003, on the Struve Arc will be created a special International Committee that may develop programs of the promotion of the Struve Arc by classic and new technologies.

When the sites will be used as sights they will be included to the cultural network of the countries. Most of them have been in public use as ground control stations since the time of the Arc measurements. This geodetic use will continue also in future and access to the sites and use of the data is guaranteed trough this channel.

The joint committee that will be created by all the ten counties has in the very beginning of its work to strengthen the policies and programmes related to the presentation and promotion of Arc sites and the Arc as a whole.

4. Management

4. (a) Ownership

No	Name	Coun try	S / M	P	Ownership: **S** = State owned **M**=Municipality owned **P** = Privately owned
1	**FUGLENAES**	NOR	**M**		HAMMERFEST CITY, Postbox 1224 K, N - 9616 Hammerfest
2	**LILLE-REIPAS**	NOR	**S**		The NORWEGIAN STATE, represented by municipality of Alta, Postbox 1403, N - 9506 Alta
3 **4**	**LOHDIZHJOKKI** **BÄLJATZ-VAARA**	NOR	**S**		The NORWEGIAN STATE, represented by municipality of Kautokeino, Postbox 68, N - 9520 Kautokeino
5	**PAJTAS-VAARA**	SWE		**P**	KARESUANDO BYS SKIFTESLAG, SE - 980 16 Karesuando
6	**KERROJUPUKKA**	SWE	**S**		The KINGDOM of SWEDEN, Swedish Environmental Protection Board, SE-106 48 Stockholm
7	**PULLINKI**	SWE		**P**	ROVA Jan, Svanstein 231B SE-957 94 Övertorneå
8	**PERRA-VAARA**	SWE		**P**	LOMAKKA Eva Lydia, Övre Kukkola 210 SE-953 91 Haparanda
9 **10** **14**	**STUOR-OIVI** **AVASAKSA** **SVARTVIRA**	FIN	**S**		The GOVERNMENT of FINLAND / Metsähallitus Vernissakatu 4, FIN - 01301 VANTAA
11	**TORNEA**	FIN		**P**	The PARISH of ALATORNIO Parasniemi, FIN - 95450 TORNIO
12	**PUOLAKKA**	FIN		**P**	ANTTILA Pentti Olavi Vanha Rastaalantie 6 B, FIN - 02620 ESPOO
13	**PORLOM II**	FIN		**P**	JARVA Matti Kalevi, Beneficiaries c/o Jarva Klaus, Jousimiehentie 10 H, FIN - 00740 HELSINKI
15 **16**	**MÄKI-PÄÄLYS** **HOGLAND, Z**	RUS	**S**		RUSSIAN FEDERATION / The Presidential Administration, Staraya pl. 4, 103132 MOSCOW
17	**WOIBIFER**	EST		**P**	VIIKSAAR Kalev, Niidu 1-10, Rakke alevik, EE –46301 LÄÄNR-VIRUMAA
18 **19**	**KATKO** **DORPAT**	EST	**S**		The ESTONIAN STATE
20	**SESTU-KALNS**	LVA		**P**	AUSMA Priede, Contact information: Region of Madona, Parish of Sausnēja “Vēņēni” LV-4841
21	**JACOBSTADT**	LVA	**S**		STATE of LATVIA
22 **23** **24**	**KARICHKI** **MESCHKANZI** **BERESNÄKI**	LTU			The STATE of LITHUANIA / National Land Service Gedimino av. 19, LT –2025 VILNUS
25 **26** **27** **28** **29**	**TUPISCHKI** **LOPATI** **OSSOWNITZA** **TCHEKUTSK** **LESKOWITSCHI**	BLR	**S**		The STATE of BELARUS, / Komzem, Krasnozvezdny per., 12, Minsk BLR - 220071 MINSK
30	**RUDY**	MDA		**P**	GALINA Rudoi, Otaci, Region of Ocnita
31	**KATERINOWKA**	UKR	**S**		The STATE of UKRAINE / Agricultural firm “ANTONIVKA”
32	**FELSCHTIN**	UKR	**S**		The STATE of UKRAINE / Agricultural firm “SMOTRICH”
33	**BARANOWKA**	UKR	**S**		The STATE of UKRAINE / Baranivka villager Ludmila I. Zhuk,
34	**STARO-NEKRASSOWKA**	UKR	**S**		The STATE of UKRAINE / Close-ended joint-stock company “SVOBODA”

4. (b) Legal status

Depending on their nature, these would be variously vested in the national survey organisation, national monuments organisation or where appropriate the local councils.

No	Name	Country	Legal status
1	**FUGLENAES**	NOR	The register number of the property is 21/2, Hammerfest City
2 3 4	**LILLE-REIPAS** **LOHDIZHJOKKI** **BÄLJATZ-VAARA**	NOR	The properties in Finnmark outside cities have no register number
5	**PAJTAS-VAARA**	SWE	The Struve Geodetic Arc survey station is on the property Kiruna KARESUANDO s:7.
6	**KERROJUPUKKA**	SWE	The Struve Geodetic Arc survey station is on the property Pajala ERKHEIKKI 1:32, Nature preservation area.
7	**PULLINKI**	SWE	The Struve Geodetic Arc survey station is on the property Övertorneå TURTOLA 1:156.
8	**PERRA-VAARA**	SWE	The Struve Geodetic Arc survey station is on the property Haparanda KUKKOLA 72:2.
9	**STUOR-OIVI**	FIN	The property belongs to the Wilderness of Tarvantovaara (“Tarvantovaaran Erämaa-alue”), “Erämaalaki”, the Finnish Law 17.1.1991/62. The register number of the property is 47-893-10-1.
10	**AVASAKSA**	FIN	The property belongs to the “Kruununpuisto” of Aavasaksa (State park of Aavasaksa). The register number of the property is 976-409-5-1.
11	**TORNEA**	FIN	The property is an independent cadastral unit registered in the Finnish Property Register. The register number of the property is 851-420-878-2.
12	**PUOLAKKA**	FIN	The property is an independent cadastral unit registered in the Finnish Property Register. The register number of the property is 277-418-2-156.
13	**PORLOM II**	FIN	The property is an independent cadastral unit registered in the Finnish Property Register. The register number of the property is 407-409-32-302.
14	**SVARTVIRA**	FIN	The property belongs to the to the National Park of Eastern Gulf of Finland. The park has been established by the law 647/1981 and sub law 932/1981. The register number of the property is 624-893-2-1.
15	**MÄKI-PÄÄLYS**	RUS	The property within its core zone is a geodetic station of the same name managed by The Federal Service of Geodesy and Gartography of Russia: Moscow, ul.Krzhizhanovskogo 14/2, GSP-7, 117801, Russia. The property within its buffer zone belongs to the *forestry quarter No.33* managed by a military forestry within the unit called “KӘU” of the Leningrad Military Region: St.-Petersburg, 191055, Russia. The property is a registered object of historical and cultural heritage,

			under the same name, Bill of Registration No.18-D of September 25, 2000, and is managed by the Department for Preservation and Use of Memorials to the History and Culture/Committee for Culture/Government of the Leningrad region: Baskov per., 7, St.-Petersburg, 191104, Russia.
16	**HOGLAND, Z**	RUS	As above but …*forestry quarter No.30*…..
17	**WOIBIFER**	EST	The property is independent cadastral unit registered in the Estonian Property Register, No 16101:001:0079.
18 **19**	**KATKO** **DORPAT**	EST	The property is owned by state, no register number.
20	**SESTU-KALNS**	LVA	The property with its buffer area has an independent cadastral unit 70920040068. Contact address is Tirgus Street 3, Madona, LV-4801, Tel: 4821464 (State Land Service of Latvia, Regional Department of Vidusdaugava).
21	**JACOBSTADT**	LVA	The property with its buffer area (the park around the point) has an independent cadastral unit 56010021749. Contact address is Rīgas Street 150, Jēkabpils, LV-5202, Tel: 5223671 (State Land Service of Latvia, Regional Department of Vidusdaugava). The property is located in the historical centre of Jēkabpils and it is included in the State Protected Cultural Monument List.
22 **23** **24**	**KARISCHKI** **MESCHKANZI** **BERESNÄKI**	LTU	The properties as state owned are not registered in the Lithuanian Property Register.
25 **26** **27** **28** **29**	**TUPISCHKI** **LOPATI** **OSSOWNITZA** **TCHEKUTSK** **LESKOWITSCHI**	BLR	The stations are on The State List of Historical and Cultural Values of the Republic of Belarus in accordance with the decision #73 of 30.04.2002 of The Scientific and Methodical Council on the Items of Historical and Cultural Heritage of the Republic of Belarus.
30	**RUDY**	MDA	The property is an independent cadastral unit; nr. of map 3436407 and nr. of parcel 036/0:9949.
31 **32** **33** **34**	**KATERINOWKA** **FELSCHTIN** **BARANOWKA** **STARO-NEKRASSOWKA**	UKR	The properties are a part of State Geodetic Network of Ukraine. Nr 34 is also an historical monument of local significance protected by the state (preservation number 1033).

4. (c) Protective measures and means of implementing them

No	Name	Coun-try	Protective measures and means of implementing them
1 2 3 4	**FUGLENAES** **LILLE-REIPAS** **LOHDIZHJOKKI** **BÄLJATZ-VAARA**	NOR	The property is served by the Act for Ancient Monuments, The Norwegian Law Nr 1978-06-09 nr 50. Kulturminneloven and the law for surveying markers: LOV-1923-07-09-1, Lov om anbringelse av signaler og merker for målearbeider.
5 6 7 8	**PAJTAS-VAARA** **KERROJUPUKKA** **PULLINKI** **PERRA-VAARA**	SWE	The Struve Geodetic Arc site is protected under the Ancient Monument Act, 1988:950, 1988-06-30
9	**STUOR-OIVI**	FIN	The property STUOR-OIVI is served by the Act for Ancient Monuments, The Finnish Law Nr 295/1963, 17.6.1963. The area around is preserved also by the law of "Tarvantovaara Wilderness", The Finnish Law Nr. 62/17.1.1991 (Erämaalaki).
10	**AVASAKSA**	FIN	The property AVASAKSA is served by the Act for Ancient Monuments, The Finnish Law Nr 295/1963, 17.6.1963. The summit area of Aavasaksa has been preserved as a State park of Aavasaksa, "Aavasaksan Kruununpuisto" since 1870s.
11	**TORNEA**	FIN	The Church of Alatornio is served by the Church Act Nr. 1054/26.11.1993
12	**PUOLAKKA**	FIN	The property PUOLAKKA is served by the Act for Ancient Monuments, The Finnish Law Nr 295/1963, 17.6.1963. There is also valid a mutual agreement between land owner, National Land Survey of Finland, Geodetic Institute and Municipality of Korpilahti for using and preserving the Struve Arc station PUOLAKKA as an historical site for triangulation and mapping and also as a modern ground control station.
13	**PORLOM II**	FIN	The property PORLOM II is served by the Act for Ancient Monuments, The Finnish Law Nr 295/1963, 17.6.1963.
14	**SVARTVIRA**	FIN	The property Svartvira is served by the Act for Ancient Monuments, The Finnish Law Nr 295/1963, 17.6.1963 and by the Law about the National Park 674/1981 and the sub degree 932/1981.
15	**MÄKI-PÄÄLYS** **HOGLAND, Z**	RUS	Protective measures are secured by: 1. The Regulations on Protective Zones and Protection of Geodetic Stations on the Territory of Russian Federation, passed by the Enactment of the Government of Russian Federation No.1170 of October 7, 1996; 2. The Federal Law on Objects of Cultural Heritage (Memorials to History and Culture) of the Peoples of Russian Federation, No.73 of June 25, 2002; 3. Departmental instructions and day-to-day management over registered monuments practiced by the Department noted in Sections 3.c.4. and 4.b. The most important instruction is "On the Rules of Registration, Securing of Preservation, Maintenance, Use and Restoration of the Immovable Memorials to History and Culture",

			passed by the order of USSR's Minister of Culture No.203 of May 13, 1986. According to it, regular personal investigation of cultural properties is performed by officials with the Department; 4. Departmental instructions and day-to-day management over the forests on the island of Gogland practiced by the "Pavlovskoye military forestry" within the military unit called "KӘU" of the Leningrad Military Region. The responsible forester is a permanent resident of the island; 5. A real way of protection is based on impossibility to do harm to the site in view since it would soon get known to the local people; every visitor is in full view.
17	**WOIBIFER**	EST	The property WOIBIFER (VÕIVERE) is a Cultural Monument and is registered in the National Heritage Register of Estonia under number 24046.
18	**KATKO**	EST	The property KATKO (SIMUNA) is a Cultural Monument and is registered in the National Heritage Register of Estonia under number 27073.
19	**DORPAT**	EST	The property DORPAT (TARTU) OBSERVATORY is a Cultural Monument and is registered in the National Heritage Register of Estonia under register number 6889.
20	**SESTU-KALNS**	LVA	Regulation about construction , supervision and protection methods of state geodetic supporting points (reference points). The Protective Zone Law protects all the geodetic points in Latvia.
21	**JACOBSTADT**	LVA	Regulation about construction , supervision and protection methods of state geodetic supporting points (reference points). The Protective Zone Law protects all the geodetic points in Latvia. As the SGA point JACOBSTADT is located in the Struve Park in the historical centre of Jēkabpils (town) it is also protected by the Law About Protection of the Cultural Monuments.
22 **23** **24**	**KARISCHKI** **MESCHKANZI** **BERESNÄKI**	LTU	The properties KARISCHKI, MESCHKANZI and BERESNÄKI as cultural heritage are served by the LAW ON PROTECTION OF IMMOVABLE CULTURAL PROPERTIES, the Lithuanian Law No I-733, 1994 12 22 and as a modern geodetic station – by the LAW ON LAND, the Lithuanian Law No I-446, 1994 04 26. There is also valid the agreements called "Statement on transferring the geodetic station for preserving" between land users and institution, which renovated the stations, Geodetic Institute of Vilnius Technical University, for using and preserving these Struve Arc stations as historical sites for triangulation and mapping and also as modern ground control stations.
25 **26** **27** **28** **29**	**TUPISCHKI** **LOPATI** **OSSOWNITZA** **TCHEKUTSK** **LESKOWITSCHI**	BLR	Protective measures are secured by 1) The State Law of May 10, 1999 "On Geodetic and Mapping Activities", the State Law of August 19, 1992 "On Culture in the Republic of Belarus" and the State Law of July 13, 1992 "On Protection of Historical and Cultural Heritage". 2) Thesis on Protection of Geodetic Stations on the Territory of Belarus, confirmed by the Resolution of the Council of Ministers of the Republic of Belarus of July 18, 1999. Protective measures are carried out and performed during regular investigations of the state geodetic network stations of the Republic of Belarus. Another way of legal protection is putting the functions of security in the hands of local executive bodies.

30	**RUDY**	MDA	The property is linked to the National Geodetic Network and is protected by the state according to the legistlation of the Republic of Moldova, Law nr. 778-XV, 27.12.2001 on “Geodesy and Gartography”.
31	**KATERINOWKA**	UKR	Protective measures are secured by Ukrainian government regulation: The government regulation on the protective measures of geodetic sites # 1284 of July 19, 1999 “PRO PORYADOK OKHORONY GEODEZYCHNYKH PUNKTIV”. The site is protected by the head of Antonivka village council Anatoliy I. Ferents..
32	**FELSCHTIN**	UKR	Protective measures are secured by Ukrainian government regulation: The government regulation on the protective measures of geodetic sites # 1284 of July 19, 1999 “PRO PORYADOK OKHORONY GEODEZYCHNYKH PUNKTIV”. The site is protected by the head of Hvardiiske village council.
33	**BARANOWKA**	UKR	Protective measures are secured by Ukrainian government regulation: The government regulation on the protective measures of geodetic sites # 1284 of July 19, 1999 “PRO PORYADOK OKHORONY GEODEZYCHNYKH PUNKTIV”.
34	**STARO-NEKRASSOWKA**	UKR	Protective measures are secured by Ukrainian national and regional regulations: The government regulation on the protective measures of geodetic sites # 1284 of July, 19, 1999 “PRO PORYADOK OKHORONY GEODEZYCHNYKH PUNKTIV”. The Legislation of Ukraine on preservation of cultural heritage # 1805-III of June 8, 2000 “PRO OKHORONU KULTURNOI SPADSCHYNY”. The Resolution of the Executive Committee of Odessa Regional Council on state registration of historic and cultural monuments # 381 of July 27, 1971 “O VZYATII NA GOSUDARSTVENNYI UCHET PAMYATNIKOV ISTORII I KULTURY”. The site is also protected by the head of Stara Nekrasivka village council Anna A. Guslenova.

4. (d) Agency/agencies with management authority

No	Name	Count-ry	Agency/agencies with management authority
1	**FUGLENAES**	NOR	Municipality of Hammerfest. Address: Postbox 1224 K, N-9616 Hammerfest Norwegian Mapping Authority, Kartverksveien 21, Servicebox 15, N-3504 Hønefoss
2	**LILLE-REIPAS**	NOR	Municipality of Alta. Address: Postbox 1403, N-9506 Alta Norwegian Mapping Authority, Kartverksveien 21, Servicebox 15, N-3504 Hønefoss
3 4	**LOHDIZHJOKKI** **BÄLJATZ-VAARA**	NOR	Municipality of Kautokeino. Address: Postbox 68, N-9520 Kautokeino. Norwegian Mapping Authority, Kartverksveien 21, Servicebox 15, N-3504 Hønefoss
5 6 7 8	**PAJTAS-VAARA** **KERROJUPUKKA** **PULLINKI** **PERRA-VAARA**	SWE	1) National Land Survey of Sweden, SE-801 82 Gävle, Sweden 2) National Heritage Board, Box 54095, SE-114 84 Stockholm, Sweden 3) Länsstyrelsen i Norrbottens län, SE-971 86 Luleå, Sweden
9 14	**STUOR-OIVI** **SVARTVIRA**	FIN	1) National Land Survey of Finland P.O. Box 84 FIN-00521 Helsinki 2) Metsähallitus 3) Geodetic Institute
10	**AVASAKSA**	FIN	1) National Land Survey of Finland P.O. Box 84 FIN-00521 Helsinki 2) Metsähallitus
11	**TORNEA**	FIN	1) National Land Survey of Finland P.O. Box 84 FIN-00521 Helsinki 2) Parish of Alatornio
12	**PUOLAKKA**	FIN	1) National Land Survey of Finland P.O. Box 84 FIN-00521 Helsinki 2) Geodetic Institute 3) Municipality of Korpilahti
13	**PORLOM II**	FIN	1) National Land Survey of Finland P.O. Box 84 FIN-00521 Helsinki 2) Geodetic Institute
15 16	**MÄKI-PÄÄLYS** **HOGLAND, Z**	RUS	1) The Federal Service of Geodesy and Cartography of Russia: Moscow, ul.Krzhizhanovskogo 14/2, GSP-7, 117801, Russia. 2) Department for Preservation and Use of Memorials to the History and Culture/Committee for Culture/Government of the Leningrad region: Baskov per., 7, St.-Petersburg, 191104, Russia. 3) The Leningrad Navy Base: Military unit 45618, Admiralteysky proezd, 1, St.-Petersburg, 190195, Russia. 4) “KƏU” of the Leningrad Military Region: St.-Petersburg, 191055
17 18 18	**WOIBIFER** **KATKO** **DORPAT**	EST	Estonian Land Board , Mustamae tee 51 P.O. Box 1635, 10602 Tallinn, Estonia

20	**SESTU-KALNS**	LVA	State Land Service of the Republic of Latvia, Geodesy board O.Vācieša Street 43, Riga, Latvia, LV-1004 Tel. +371 7815470; +371 7815471 Fax. +371 7612736 e – mail: geo@vzd.gov.lv
21	**JACOBSTADT**	LVA	1) As above (State Land Service) and 2) Council of Jēkabpils Brīvības Street 120, Jēkabpils, Latvia, LV-5200 Tel. +3715232155 e – mail: mail@jdome.zednet.lv
22 **23** **24**	**KARISCHKI** **MESCHKANZI** **BARESNÄKI**	LTU	1) Department of Cadastres and Geodesy of National Land Service under the Ministry of Agriculture of Lithuania, Gedimino av. 19, LT-2025 Vilnius, Lithuania. Tel: +370 5 2398434, Fax +370 5 2391331, e-mail: nzt@zum.lt 2) Geodesy, Land Planning and Geographical Information Systems (GIS) service of Urban Development Department of Municipality of Vilnius, Gedimino av. 35/1, LT-2600 Vilnius, Lithuania. 3) Geodetic Institute of Vilnius Technical University, Sauletekio av. 11, LT-2040 Vilnius, Lithuania, Tel: +370 5 2744705, Fax +370 5 2744705, e-mail: gi@ap.vtu.lt
25 **26** **27** **28** **29**	**TUPISCHKI** **LOPATI** **OSSOWNITZA** **TCHEKUTSK** **LESKOWITSCH**	BLR	1) Committee for Land Resources, Geodesy and Cartography Under the Council Of Ministers of the Republic of Belarus Belarus, 220071, Minsk, Karsnozvezdny per., 12, Komzem, Tel. : +375 017 288 27 25 2) Department for Protection of Historical and Cultural Heritage and Restoration Belarus, 220030, Minsk, ul. Lenina, 22 Tel.: +375 017 227 42 95
30	**RUDY**	MDA	1) The Municipality of Rudy 2) The State Agency for Land Relations and Cadastre which is the central authority of public administration which ensures the implementation of Government policy in the area of land tenure, cadastre, geodesy and cartography on the territory of Moldova. The Agency reports to the Government of Moldova.
31 **32** **33**	**KATERINOWKA** **FELSCHTIN** **BARANOWKA**	UKR	State Service of Geodesy, Cartography and Cadastre of Ukraine, Head of service – Ivan D. Makarenko, phone: +380 44 559-73-89, Deputy director – Borys D. Lepetjuk, phone: +380 44 573-26-82, 54, Popudrenka str., Kyiv, 02094, Ukraine, fax: +380 44 573-42-13, e-mail: ukrgeo@geomatica.kiev.ua, lepetjuk@geomatica.kiev.ua
34	**STARO-NEKRASSOWKA**	UKR	1) As above (State Service of Geodesy) and 2) State Committee for Preservation of Cultural Heritage in Odessa Region Head of Committee – Nataliya A. Shterbul, phone: +380 48 222-22-78 Deputy Head – Valeriy Y. Suntsov, phone: + 380 48 234-64-99 43, Troitska str., Odessa, 65045, Ukraine fax: + 380 48 234-52-62 e-mail: nasledie@paco.net www.nasledie.odessa.gov.ua

4. (e) Level at which management is exercised and name and address of responsible person for contact purposes

COUNTRY	Level at which management is exercised and name and address of responsible person for contact purpose
NORWAY	Management is exercised on a yearly basis within budget and management practice of respective municipality. For FUGLENAES the responsible person is Gerd Hagen, Address: Hammerfest kommune, Postbox 1224 K, N-9616 Hammerfest. For LILLE-REIPAS the responsible person is Olav Olsen, Address: Alta kommune, Postbox 1403, N-9506 Alta For LOHDIZHJOKKI and BÄLJATZ-VAARA the responsible person is Alf Isak Keskitalo, Address: Kautokeino bygdetun, N-9520 Kautokeino
SWEDEN	Management is exercised according the need on a yearly basis within budget and maintenance practice of the National Land Survey of Sweden, SE-801 82 Gävle, Sweden
FINLAND	Management is exercised according to need on a yearly basis within budget and maintenance practice of National Land Survey of Finland. The responsible person is Pekka Tätilä, Tel +358 20541 5593, e-mail pekka.tatila@nls.fi Address: P.O. Box 84 FIN-00521 Helsinki
RUSSIA	1) Management is exercised by the official with responsibility for The Federal Service of Geodesy and Cartography of Russia for the project “Struve Geodetic Arc”: Federal State Unitary Enterprise “Aerogeodeziya”, Director General Dr. YUSKEVICH A.V. Contact address: 8 Bukharestskaya str., St.-Petersburg, 192102, Russia tel. +7 812 1664924, 1662979, fax +7 812 1665641, E-mail: aerogeod@agspb.ru 2) Management is exercised by Deputy Chairman of the Committee for Culture of the Government of the Leningrad region, Director of the Department for Preservation and Use of Memorials to the History and Culture: Mr VASILIEV S.G. Contact address: 7, Baskov per., St.-Petersburg, 191104, Russia, tel/fax +7 812 2723819 3) Management is exercised by the official in responsibility with the Leningrad Navy Base for administrative and technical matters regarding the island of Gogland: Marine Engineer Service, lieutenant colonel SERZHENKO D.M. Contact address: Military unit 45618, Morskaya Inzhenernaya Sluzhba, 1, Admiralteysky proezd, St.-Petersburg, 190195, Russia. tel. +7 812 2770335, fax +7 812 2772429. 4) Management is exercised by Head of “KЭU” of the Leningrad Military Region Colonel TUSIKOV V.P. Contact address: St.-Petersburg, 191055, Russia, Leningradsky Voenny Okrug, Kvartirno-ekspluatazionnoe Upravleniye, tel. +7 812 3182431, fax +7 812 2730205.
ESTONIA	Management is exercised according the need on a yearly basis within budget and maintenance practice of Estonian Land Board. The responsible person is Raivo Vallner, P.O. Box 1635, 10602 Tallinn, Estonia
LATVIA	For SESTU-KALNS State Land Service of Latvia, Geodesy Board. For JACOBSTADT State Land Service of Latvia, Geodesy Board, contact information see 4d. Management is exercised on a yearly basis within Council of Jēkabpils budget and management practice. The responsible person is R. Sirmocičs, Address: Brīvības Street 120, Jēkabpils, Tel. +3715236143, e – mail: pd@jdome.zednet.lv

LITHUANIA	Management is exercised on a yearly basis within National Land Service under the Ministry of Agriculture of Lithuania budget and management practice. The responsible person is Vitalija Juceviciute, Address: National Land Service under the Ministry of Agriculture, Gedimino av. 19, LT-2025 Vilnius, Lithuania. Tel: +370 5 2398434, Fax +370 5 2391331, e-mail: nzt@zum.lt
BELARUS	Committee for Land Resources, Geodesy and Cartography Under the Council Of Ministers of the Republic of Belarus Belarus, 220071, Minsk, Karsnozvezdny per., 12, Komzem, Tel. : +375 017 288 27 25
MOLDOVA	Management is exercised on a yearly basis within Municipality of Rudy budget and management practice.
UKRAINE	State Service of Geodesy, Cartography and Cadastre of Ukraine, Head of service – Ivan D. Makarenko, phone: +380 44 559-73-89, Deputy director – Borys D. Lepetjuk, phone: +380 44 573-26-82, 54, Popudrenka str., Kyiv, 02094, Ukraine, fax: +380 44 573-42-13, e-mail: ukrgeo@geomatica.kiev.ua, lepetjuk@geomatica.kiev.ua

4. (f) Agreed plans related to property

In general, tourism agencies, local and regional agencies have not yet integrated the Struve Arc into their plans. Opportunities for this integration will be the task of the "Committee of the Struve Arc".

4. (g) Sources and level of finance

COUNTRY	Sources and level of finance
NORWAY	Adequate financing according to above mentioned agreement, on average 1000 €/year/site. The vegetation is slow growing at Norwegian sites so only a minimum maintenance is required.
SWEDEN	Adequate financing for a periodic checking and maintenance of core areas will be guaranteed by the National Land Survey of Sweden in connection with resurveys.
FINLAND	Adequate financing for checking and maintenance, in average 1000 €/year/site, will be guaranteed by National Land Survey of Finland.
RUSSIA	Regular supervision over preservation and use of cultural properties is financed from the funds of the Committee for Culture of the Government of Leningrad region. Regular supervision over preservation and use of forest blocks on the island of Gogland is financed from the funds of the Ministry of Defence of Russia.
ESTONIA	Resources are being sought for the special aim of protecting and managing over the SGA properties. Help is required for more regular supervision and keeping good appearance of the properties.
LATVIA	The supervision of the properties is financed from the budget of State Land Service of Latvia. The supervision of the property in Jēkabpils i.e. Struve Park is financed from the budget of the Council of Jēkabpils.
LITHUANIA	Adequate financing according above in section 4 (c) mentioned agreement, in average 300 €/year/site.
BELARUS	Resources are being sought for the special aim of protecting and managing the SGA stations Tupishli, Lopaty, Ossovnitsa, Chekutsk and Leskovichy, except for those spent on common supervision activities of the state geodetic grid of the Republic of Belarus. Help is required for more regular supervision, keeping good appearance of the properties and for making a memorial plaque.
MOLDOVA	Some initial financing resources were provided by IIHSM
UKRAINE	Resources are being sought for the special aim of protecting and managing over the SGA property, except for those spent by State Service of Geodesy, Cartography and Cadastre of Ukraine on reconstruction activities.

4. (h) Sources of expertise and training in conservation and management techniques

COUNTRY	Count-ry	Sources of expertise and training in conservation and management techniques
NORWAY	NOR	These sources are provided by the respective Municipalities and by Norwegian Mapping Authority under supervision of the National Board of Antiquities of Norway.
SWEDEN	SWE	Sources are provided by the National Land Survey of Sweden in collaboration with the National Heritage Board.
FINLAND	FIN	These sources are provided by National Land Survey of Finland under supervision of the National Board of Antiquities of Finland.
RUSSIA	RUS	Special expertise are provided by The Federal Service of Geodesy and Cartography of Russia for the term from June 1 to December 31, 2003 to secure the job of its special representative for the promotion of the project "Struve Geodetic Arc". Regular expertise over preservation and use of cultural properties is managed by the Committee for Culture of the Government of Leningrad region. Regular expertise over preservation and use of forest blocks on the island of Gogland is managed by the Ministry of Defence of Russia.
ESTONIA	EST	Maaamet, the National Land Survey of Estonia
LATVIA	LVA	The State Land Service of Latvia, Geodesy Board, provides these sources.
LITHUANIA	LTU	These sources are provided by National Land Service under the Ministry of Agriculture under supervision of the National Commission of Antiquities of Lithuania.
BELARUS	BLR	These sources are provided by Komzem mentioned in Section 4d. Help may be required in future on training the guides and providing illustrative material.
MOLDOVA	MDA	These sources are provided by the Municipality of Rudi.
UKRAINE	UKR	These sources are secured by Ukrainian national regulations: The government regulation on the protective measures of geodetic sites # 1284 of July 19, 1999 "PRO PORYADOK OKHORONY GEODEZYCHNYKH PUNKTIV". The regional regulations for STARO-NEKRASSOWKA: The Legislation of Ukraine on preservation of cultural heritage # 1805-III of June 8, 2000 "PRO OKHORONU KULTURNOI SPADSCHYNY" The Resolution of the Executive Committee of Odessa Regional Council on state registration of historic and cultural monuments # 381 of July 27, 1971 "O VZYATII NA GOSUDARSTVENNYI UCHET PAMYATNIKOV ISTORII I KULTURY".

4. (i) Visitors facilities and statistic

No	Name	Country	Visitors facilities and statistic
1	**FUGLENAES**	NOR	The property FUGLENAES is situated in a small park open for people to visit. Easy access. To the northeast is a school only 20 m away. In all other directions there is open view. It has been calculated that more than 5000 persons will visit the station yearly. Information about The Struve Geodetic Arc exists already.
2	**LILLE-REIPAS**	NOR	The property LILLE-REIPAS is situated in an open landscape and according to the law in Norway everybody has right to go and visit the property. The property is situated in an area without trees near the point. A path is leading the 2 km up from the road. The height difference from the road is about 100 m. Estimated walking time from the road and up to the point is one hour. From Raipas there is a nice view of the surrounding terrain. It has been calculated that more than 500 persons will visit the station yearly when the information posters are organized.
3	**LOHDIZHJOKKI**	NOR	The property LUVDIIDCOHKKA is situated in an open landscape and according to the law in Norway everybody has right to go and visit the property. The property is situated in an area without trees. A path is leading from the road to the lake Unna Goastejavrras from which one can walk straight south to the point. Estimated walking time from the road and up to the point is one hour. From LUVDIIDCOHKKA there is a nice view of the surrounding terrain. It has been calculated that more than 200 persons will visit the station yearly when the information posters are organised.
4	**BÄLJATZ-VAARA**	NOR	The property BAELLJASVARRI is situated in an open landscape and according the law in Norway everybody has right to go and visit the property. The property is situated about 90 m above the timberline so there are no trees near the point. A path is leading from the little village Avzi and 2,5 km up to the point. The height difference from the nearest road in Avzi is about 250 m. Estimated walking time from the road and up to the point is one hour. From Baelljasvarri there is a nice view of the surrounding terrain. It has been calculated that more than 200 persons will visit the station yearly when the information posters are organised.
5	**PAJTAS-VAARA**	SWE	The TYNNYRILAKI mountain is east of lake Paittasjärvi, where the 445 m high mountain is sparsely covered with birch trees. The present name TYNNYRILAKI refers to the type of signal used at the SGA survey, 'tynnyri' meaning 'barrel'. It is within a low populated area, nearest settlement being Paittasjärvi at a public road (to Karesuando, the northernmost road in Sweden). Access to the TYNNYRILAKI hilltop is over a 6.5 km private gravel road. The walk uphill is about 1.0 km. From the top there is a wide view in most directions, over to Finland as well as westwards over desolate parts of Sweden.
6	**KERROJUPUKKA**	SWE	The JUPUKKA triangulation station is within the Jupukka Nature Preservation Area, and close to a public road. A parking lot is arranged

			(0.7 km from public road). A hiking path runs through the area, passing over the hill where the triangulation for the Struve Geodetic Arc was made. The spot is easily reached by this trail less than 1 km to walk.
7	**PULLINKI**	SWE	The property and mountain PULLINKI is a skiing resort, with hotel, restaurant, etc. open during the winter season. A public road and parking lots make access easy. During winter season there are ski lifts to a summit nearby the triangulation place. For tourists there is an observation tower, and a tourist hut on the arc measurement summit. It is about a 1,5 km walk from the restaurant area uphill to the Struve Geodetic Arc point. The Maupertuis' arc measurement monument is also a tourist attraction.
8	**PERRA-VAARA**	SWE	PERÄVAARA is within a forest country, and is not recognised as a high or steep mountain. It is about 3-4 km from nearest public road.
9	**STUOR-OIVI**	FIN	The property of STUOR-OIVI is located in the wildness, at the National Park of Tarvantovaara. It is some 25 km away from the closest public road. So it is mostly the hikers who are visiting this remote summit.
10	**AVASAKSA**	FIN	Aavasaksa has a centuries long international fame as a faraway place, which offers a splendid chance to admire the midnight sun and the beautiful river valley scenery, which is one of the Finnish national landscapes. Tornio valley was in fact one of the best-known Finnish areas in Western Europe in the 18^{th} and 19^{th} centuries. The Emperor's Cabin was built in 1882 as the hunting lodge of Tsar Alexander II at the summit. The richly decorated cabin has been restored and now serves as a museum. The look out tower lies close by the Emperor's Cabin, in fact just on the place were Arc measurement was carried out. The National Park was established in 1878 as one of the first in Finland and also in the World. The park and its properties have been under development and reconstruction during recent years. There are many services, like coffee shops and places for accommodation close to the summit.
11	**TORNEA**	FIN	The Church of Alatornio is open for visitors during summer months. Then some 20-30 people will daily visit the Church. And of course a big number of parishioners will attend a church service every Sunday.
12	**PUOLAKKA**	FIN	The property PUOLAKKA is situated in a forestry landscape and according the law in Finland every body has right to go and visit the property. While this is a special commemorate site for triangulation, surveying and mapping activities, a path has been built from common road to the station. On the spot has been placed also boars telling about the history of Struve Arc and triangulation and mapping as a whole..
13	**PORLOM II**	FIN	The property PORLOM II is situated in a forestry landscape and according the law in Finland every body has right to go and visit the property A path is going from common road to the station
14	**SVARTVIRA**	FIN	The property of Svartvira is located in the National Park of Eastern Gulf of Finland on the island called Mustaviira (i.e Svartvira in Swedish). The national park comprises the outer archipelago of Finland's easternmost coastal municipalities. The hundred or so islands and islets making up this archipelago lie haphazardly here and there across a 60 km wide marine belt, far from the mainland and any inhabited islands. It is about one hour's boat trip from the mainland. Being a part of a national park, there are no special services for

			visitors, but it is allowed for everybody to enter the island and camping is also permitted at Mustaviiri.
15 **16**	**MÄKI-PÄÄLYS** **HOGLAND, Z**	RUS	Brief inscriptions are available on the similar plaques attached to either property. More considerable information is available in published sources, which may be copied. Overnight accommodation in a village house and meals for several persons are available by agreement with the forester (in advance). The property MAKI-PÄÄLYS is within 0,5 hour by foot up the clean mountain path, or by a motorcycle along another road. The property HOGLAND, POINT Z is within 15 minutes of walk from the harbour along a sandy road. No statistical information is yet available except for private communications of single visits to the sites. The new governmental policy of openness of the former militarised island has yet to produce substantial statistics.
17 **18**	**WOIBIFER** **KATKO**	EST	These sites are the terminals of Simuna baseline. Brief inscriptions are available on the property KATKO (SIMUNA).
19	**DORPAT**	EST	Tartu Observatory is open for visitors.
20	**SESTU-KALNS**	LVA	The station SESTU-KALNS is situated on the hill surrounded with woods. The access to the point is rather difficult because there is no special path made from the nearest road to the station for visitors' purpose. No statistical information is yet available.
21	**JACOBSTADT**	LVA	The property JACOBSTADT is situated in Struve Park, which is located between Brīvības street, V.Strūves street and R.Blaumaņa street in the centre of Jēkabpils (town). This site is recommended as a tourist object in several site-seeing materials about Jēkabpils. Under these circumstances the number of visitors could be rather high.
22 **23** **24**	**KARISCHKI** **MESCHKANZ** **BERESNÄKI**	LTU	The properties are situated in a forestry landscape and according the law in Lithuania everybody has right to go and visit the properties. While these are special commemorate sites for triangulation, surveying and mapping activities, a path has been built from the road to the stations. Around the spot has been placed a fence and also board with information on historical and present day coordinates of the station. It has been calculated that about 150 persons will visit each station yearly.
25 **26** **27** **28** **29**	**TUPISCHKI** **LOPATI** **OSSOWNITZA** **TCHEKUTS** **LESKOWITSCHI**	BLR	Full information concerning stations Tupishki, Lopaty, Ossovnitsa, Chekutsk and Leskovichi is available in published sources, which may be copied. Visiting is possible at any time; overnight accommodation in an hotel in the nearest community is available No statistical information is available except for private communications of single visits the sites.
30	**RUDY**	MDA	The property RUDY is situated in a forestry landscape and according to the law in Moldova every body has right to visit the property.
31 **32** **33** **34**	**KATERINOWKA** **FELSCHTIN** **BARANOWKA** **STARO-NEKRASSOWKA**	UKR	The sites have been visited only by surveyors. A memorial monument is placed in front of every property an explanation of the role of the station. Overnight accommodation available in Khmelnytskiy city/30 and 31, in Yarmolyntsi town/32 and in Izmail town/33 within range of 25 / 20 / 25 and 5 km respectively.

4. (j) Property management plan and statement of objectives

There is currently no special joint management plan, because ten countries have been establishing their own management and research work first. In the next phase these ten Struve Arc countries will establish a management mechanism. The Resolution 3 of Minsk Meeting, September 2003 has stated:

”In order to preserve Struve Arc points selected, all delegates recommend that a committee of the of the Struve Arc be created which would coordinate the activities of the ten countries in a manner beneficial in the long term preservation of the selected points of the Struve Arc. The committee will be composed of the representatives of the National Survey agencies of the ten countries.”

Further more the management committee would receive a yearly report from each of the countries on the state of conservation of the selected points. It would report periodically to the World Heritage Committee on the state of conservation of the Struve Arc as a whole. It may develop programs of the promotion of the Struve Arc by classic and new technologies. It may also develop a logo for the Arc. It may undertake other tasks as appropriate.

The State Parties of the Struve Arc will have their next meeting in 2004 in Moldova to among other common things to make a management plan and make a statement of objectives.

4. (k) Staffing level

As will be seen in the documentation, the feature is such that no permanent staff will be required to supervise it. All that will be needed is a routine inspection maybe on an annual or semi-annual cycle, to ensure that any damage is repaired and the site in general is well maintained. This will differ from area to area but would be carried out by representatives of the local population, the national survey organisation or national antiquity organisation with very little cost involved.

5. Factors Affecting the Property

a. Development Pressures
- as shown below in table

b. Environmental Pressures
- there is no special environmental pressure within any site

c. Natural disasters and preparedness
- as shown below in table

d. Visitors/tourism pressures
- as shown below in table

e. Number of inhabitants within property, buffer zone
- there is nobody living within any property

No	Name	Count-ry	a	c	d
1	**FUGLENAES**	NOR	No. Under control by Hammerfest Municipality.	No	The area is already organised for visitors, so it does not make any pressure on the property.
2 3 4	**LILLE-REIPAS** **LOHDIZHJOKKI** **BÄLJATZ-VAARA**	NOR	No	No	Number of visitors is so limited, that it does not make any pressure on the property
5 8	**PAJTAS-VAARA** **PERRA-VAARA**	SWE	No	No	No
6	**KERROJUPUKKA**	SWE	No	No	Small number of visitors to the Nature Preservation Area.
7	**PULLINKI**	SWE	No	No	Skiing tourists at nearby skiing lift, out-look tower and Maupertuis' monument.
9 10 11 12 13 14	**STUOR-OIVI** **AVASAKSA** **TORNEA** **PUOLAKKA** **PORLOM II** **SVARTVIRA**	FIN	No	No	No
15 16	**MÄKI-PÄÄLYS** **HOGLAND, Z**	RUS	Encroachment and adaptation of the vicinity of the two properties' core or buffer zones are possible, due to high environmental qualities, isolation of the zones and lack of population and therefore incomes. No special contingency plans are needed except for strengthening legal protection instruments. The status of Federal Significance is supposed to be adequate measure against any adaptation within the properties.	Fires may have serious effect on qualities of the buffer zones surrounding the properties, however, not on the properties themselves. Ordinary activity of the state fire-fighting services should include the island territory, however, there is no information of that.	Possible visitors' pressure might come into force if no management is developed on the properties. Danger of fires is the most likely when dry spring and summer seasons. Another threat might be damage of the constructions at either site, i.e. deterioration of the exteriors. Under current circumstances a safe visitors' capacity at either property can be estimated as 10 persons per week.
17 18 19	**WOIBIFER** **KATKO** **DORPA**	EST	No	No	No
20 21	**SESTU-KALNS** **JACOBSTADT**	LVA	No	No	Number of visitors might be as high at 21 because the Struve Park is recommended as the place to visit in many site-seeing materials. This circumstance does not show the tourism as a pressure.
22 23 24	**KARISCHKI** **MESCHKANZI** **BERESNÄKI**	LTU	No	No	Number of visitors is so limited that it does not make any pressure on the property.
25 26 27 28 29	**TUPISCHKI** **LOPATI** **OSSOWNITZA** **TCHEKUTSK** **LESKOWITSCHI**	BLR	No special contingency plans are needed except for strengthening legal protection instruments. The status of State Significance is supposed to be adequate measure against any illegal activities in properties zones.	No	Possible visitors' pressure might come into force. Treat might be damage of the constructions at either site, i.e. deterioration of the exteriors. Under current circumstances a safe visitors capacity is not limited.
30	**RUDY**	MDA	No	No	Number of visitors is so limited, that it does not make any pressure on the property.
31 32 33 34	**KATERINOWKA** **FELSCHTIN** **BARANOWKA** **STARO-NEKRASSOWKA**	UKR	Encroachment and adaptation of the vicinity of the property core or buffer zones are not possible.	Possibilities of natural disasters are minimized due to geographical position of property.	No

6. Monitoring

6. (a) Key indicators for measuring state of conservation

“No applicable”

6. (b) Administrative arrangements for monitoring property

The property is monitored by the agencies in section 4.d.

6. (c) Results of previous reporting exercises

COUNTRY	Results of previous reporting exercises
NORWAY	The most recent reports of 1999 - 2003 reveal no harm done to the sites.
SWEDEN	At visits from the National Land Survey in 2001 - 2003 no harm to the sites was observed.
FINLAND	The most recent reports of 2001-2002 reveal no harm done to the sites.
RUSSIA	According to the document quoted in Section 3.c, item 1, no harm has been done to the property other than the paint cover of the stand (established in 2000) was renovated for Mäki-Päälys.
ESTONIA	The recent reports from 2001-2003 reveal no harm done to the property
LATVIA	The most recent report of 2002 reveals no harm done to the property.
LITHUANIA	The private communications in 2002 reveal no harm done to the property.
BELARUS	The earlier private communications of 2001 – 2002 reveal no harm done to the properties. No sources are yet published on that matter.
MOLDOVA	The most recent report of 2002 reveals no harm done to the property.
UKRAINE	For last 10 years geodetic observations have been performed on sites. Executive surveyors revealed that no harm has been done to the property.

7. Documentation

7. (a) Photographs, slides and, where available, film/video

1. The monument of the arc at the northern terminal **FUGLENAES (1).** Hammerfest, Norway.
2. The inscriptions on the monument of the Arc, **FUGLENAES (1).** Hammerfest, Norway.
3. The monument on the site **FUGLENAES (1**). Hammerfest, Norway.
4. The Globe on the monument at the site **FUGLENAES (1).** Hammerfest, Norway.
5. The site **LOHDIZHJOKKI (3)** on the summit of Luvdiidhcokka. Kautokeino, Norway.
6. The site **BÄLJATZ-VAARA (4)** on the summit of Baelljasvarri. Kautokeino, Norway.
7. **PAJTASVAARA (5)** on the summit of Tynnyrilaki, Kiruna, Sweden.. (2003)
8. **PAJTASVAARA (5).** A view from the summit of Tynnyrilaki to the northeast. Kiruna, Sweden. (2003)
9. **KERROJUPUKKA (6**). The mountain Jupukka seen from south.. Pajala, Sweden. (2003)
10. **KERROJUPUKKA (6).** The summit of Jupukka. Pajala, Sweden. (2003)
11. **PULLINKI (7**). The mountain Pullinki from northeast. Övertorneå, Sweden. (2003).
12. **PULLINKI (7**). The summit of Pullinki where arc measurements were made. Sweden. (2001).
13. **PERRA-VAARA (8**). The cross-mark from arc measurement on Perävaara. Haparanda, Swden. (2002).
14. **AVASAKSA (10**). The summit of Aavasaksa Mountain and the lookout tower. Ylitornio, Finland. (2002).
15. **AVASAKSA (10).** Engravings on the bedrock made by tourists at Aavasaksa, Ylitornio, Finland. (2002).
16. **AVASAKSA (10).** An information map of Aavasaksa. Yli-tornio, Finland. (2002).
17. **TORNEA (11).** The church of Alatornio. Tornio, Finland. (2002).
18. **TORNEA (11).** A view from the tower of Alatornio church to the north. Tornio, Finland. (2003).
19. **TORNEA (11).** A detail from a roof rafter in the tower of Alatornio church. Tornio, Finland. (2003).
20. **TORNEA (11).** The tower of the church of Alatornio. Tornio, Finland. (2002).
21. **TORNEA (11).** A view from the tower of Alatornio church to the south. Tornio, Finland. (2003).
22. **TORNEA (11).** The interior from Alatornio churc. Tornio, Finland. (2002).
23. The information board near the arc site **PUOLAKKA (12).** Korpilahti, Finland. (2002).
24. **SVARTVIRA (14).** The remnants of the ruined triangulation tower on Mustaviiri.. Pyhtää, Finland. (2002).
25. At the arc site **SVARTVIRA (14**), Pyhtää, Finland. (2002).
26. The arc site **SVARTVIRA (14**). The centre point right to the aiming circle. Pyhtää, Finland. (2002).
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58. The memorial plaque at the arc site **KATERINOWKA (31).** Antonivka, Ukraine. (2003).
59. The centre mark of the arc site **FELSCHTIN (32).** Hvardiiske, Ukraine (2003).
60. The arc site **FELSCHTIN (32).** Hvardiiske, Ukraine. (2003).
61. The ridge of the arc site **FELSCHTIN (32).** Hvardiiske, Ukraine. (2003).
62. The memorial plaque at the arc site **FELSCHTIN (32).** Hvardiiske, Ukraine. (2003).
63. The centre mark of the arc site **BARANOWKA (33).** Baranivka, Ukraine (2003).
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65. The memorial plaque on the monument of **STARO-NEKRASSOWKA (34).** Nekrasivka, Ukraine.
66. **STARO-NEKRASSOWKA (34).** The monument at the S terminal of the arc. Nekrasivka, Ukraine. (2003).

The following photos are also copied on slide film and annexed to the Nomination:

2	**3**	**4**	**6**	**17**	**19**	**26**	**28**	**32**	**38**	**40**	**46**	**54**	**60**	**62**	**65**	**66**

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See section 4. (j).

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7. (d) Address where inventory, records and archives are held

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NORWAY	Hammerfest kommune (for site Fuglenaes) P.O. Box 1224 K N-9616 Hammerfest Norwegian Mapping Authority (for all four Norwegian sites) P.O. Box 15 N-3504 Hønefoss
SWEDEN	1) National Land Survey of Sweden SE-801 82 Gävle 2) National Heritage Board Box 5405 SE-114 84 Stockholm
FINLAND	National Land Survey of Finland tel. +358 20541 5593 fax. +358 20541 5454 P.O. Box 84 FIN – 0521 Helsinki
RUSSIA	1) Government of the Leningrad region, Committee for Culture, Department for Preservation and Use of Memorials to History and Culture, 7, Baskov per., St-Petersburg, 191104, Russia, tel/fax +7 812 2723819. The code name “Gogland – Duga Struve”. 2) Federal State Unitary Enterprise “Aerogeodeziya”, 8 Bukharestskaya str., St.-Petersburg, 192102, Russia, tel. +7 812 1664924, 1662979, fax +7 812 1665641, e-mail: aerogeod@agspb.ru The code name “Duga Struve. 10.16.2596 – 2003”.
ESTONIA	Estonian Land Board P.O. Box 1635, 10602 Tallinn, ESTONIA
LATVIA	National Land Service of Latvia, Geodesy board tel. +371 7815470; +371 7815471 fax. +371 7612736 e-mail: geo@vzd.gov.lv O.Vācieša Street 43, Riga, LV-1004, LATVIA
LITHUANIA	National Land Service under the Ministry of Agriculture Gedimino av. 19 LT-2025 Vilnius, LITHUANIA
BELARUS	1) Committee for Land Resources, Geodesy and Cartography Under the Council Of Ministers of the Republic of Belarus tel. : +375 017 288 27 25 Belarus, 220071, Minsk, Karsnozvezdny per., 12, Komzem, 2) Department for Protection of Historical and Cultural Heritage and Restoration tel.: +375 017 227 42 95 220030, Minsk, ul. Lenina, 22, BELARUS
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The Struve Geodetic Arc: **Finland**

Minister of Culture

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The Struve Geodetic Arc: **Latvia**

Ministry of Culture
or agency responsible for World Heritage activities

/Dace Neiburga/
UNESCO LNK ģenerālsekretāre
18.12.2003.

18.12.2003.

18.12.2003.

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The Struve Geodetic Arc: **Lithuania**

Roma Žakaitienė
Minister of Culture

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Veaceslav Madan,
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Børge Brende

Minister of Environment,
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Mitrofanova Eleonora V.

Ministry of Culture
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First Deputy Minister
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Ministry of culture and art of Ukraine

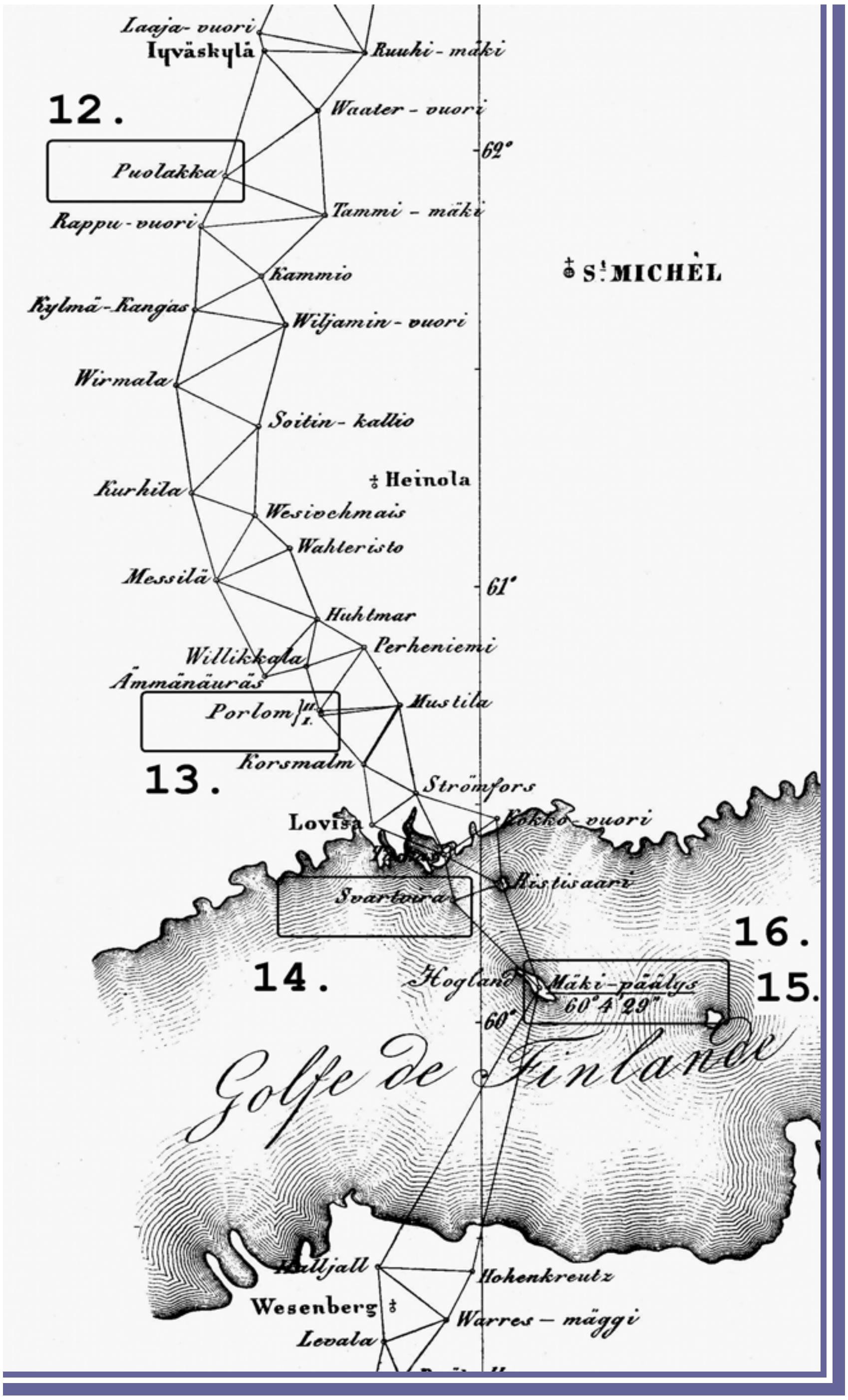
Ministry of Culture
or agency responsible for World Heritage activities

Appendix I

BACKGROUND

of

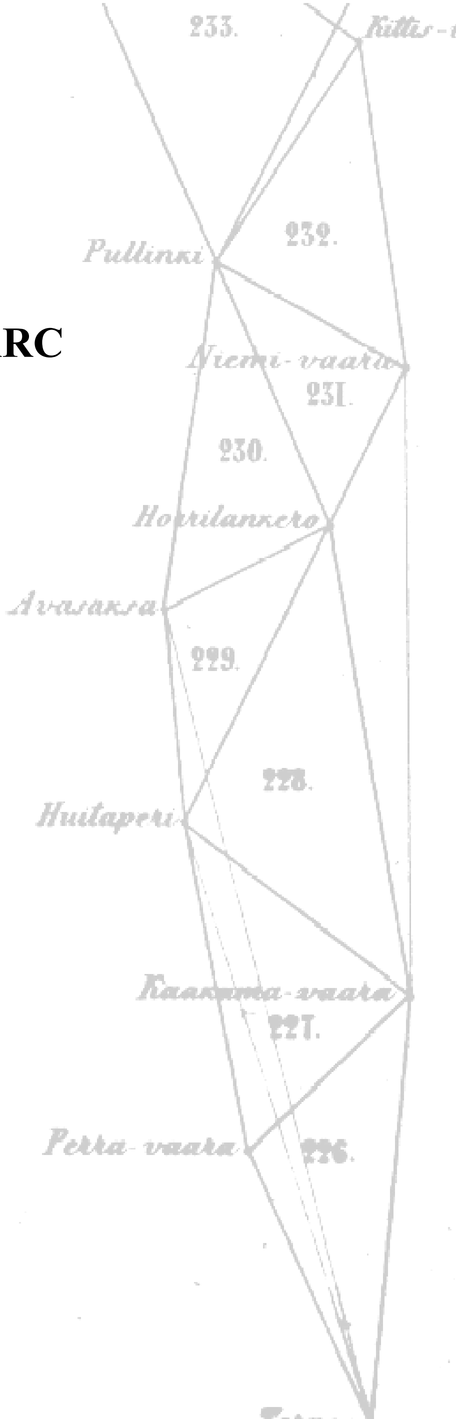
THE STRUVE GEODETIC ARC



BACKGROUND

of

THE STRUVE GEODETIC ARC



Appendix I

to

Nomination of the

STRUVE GEODETIC ARC

for inscription on the

WORLD HERITAGE LIST

January 2004

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BACKGROUND

of

THE STRUVE GEODETIC ARC

INTRODUCTION

The Scientific Conference in Tartu on August 28, 1993 agreed the following Resolution No 1.

"Considering the scientific, historical and practical importance of the measurement of the arc of meridian through Tartu, made by F.G.W. Struve,

Urge the governments of those countries that still possess relics of that enterprise to take all possible steps to preserve those relics, including an approach to UNESCO to declare them to be World Heritage sites."

This idea for seeking a declaration to preserve the remaining Struve Arc points as a World Heritage site was originally presented in same Tartu Conference in the paper prepared by Aarne Veriö, [Veriö 1994].

A corresponding resolution 1/2 1994 was then made at the FIG Congress at Melbourne in 1994.

Since 1994/5 the National Survey Organisations within the countries of the Struve Arc and the International Institution for the History of Surveying & Measurement (a Permanent Institution within the International Federation of Surveyors, FIG) has been working on a project to achieve recognition of the Struve Geodetic Arc as a UNESCO World Heritage site. But what is the Struve Geodetic Arc and what, in this context, is a World Heritage Site? Before answering these questions it is necessary to fill in some of the background to the project and discuss the determination of the parameters of the earth in terms of its size and shape.

BACKGROUND

Since the time of Eratosthenes, (c276 BC-c195 BC), the dimensions of the earth have been determined by surveying techniques in the measurements of arcs of lines of longitude (see Figure 1). In fact the theory developed by Eratosthenes remained in use until the era of satellite geodesy. This is the use of orbiting satellites to refine the determination of knowledge of the size and shape of the earth.

Many famous names in the fields of astronomy, mathematics and surveying have been involved in the gradual improvement in techniques, equipment and results. Among these one might mention Fernel, Picard, the Cassinis, Newton, Bouguer, La Condamine, La Caille, Maupertuis, Gauss, Delambre, Mechain, Airy, Everest and many others. Notice how many of these were Frenchmen.

The focus of this paper is another name, that of F.G.W.Struve, who made an important contribution during the 19th century. Such was the importance of the work by Struve and his collaborators (particularly Tenner, Selander and Hansteen) that it is the aim that many of his survey points that still remain can be designated as world heritage monuments. But more of Struve later. To put his work in context some background detail is necessary.

THE PROBLEM

Prior to Eratosthenes, back to the time of Pythagoras around 500 BC, it had been known that the earth was not flat but of some spherical shape. Why spherical was the next step after flat and not some other shape is open to conjecture. At the time however the sphere was considered to be the perfect shape, perhaps because of its regularity in all directions, and could well have been selected in this case just on that assumption. The fact that it turned out to be a correct choice would then, have been pure luck.

The problem over the intervening centuries has been to determine its exact shape and size. This is no easy problem when considering the huge size involved. While it was considered to be a true sphere the problem resolved itself to one of just determining its size, but by the time of Isaac Newton in the second half of the 17th century even the idea of a true sphere was being questioned. (By 'true sphere' and other terms mentioned later, is meant the sea level surface assumed continuous around the earth. In relation to the overall size of the earth the topography is insignificant).

Why was knowledge of these parameters of importance? This can be illustrated simply by saying that if Christopher Columbus had known the true size of the earth; he would not have gone where he did. By working with a figure that was much too small he had a distorted idea of the earth he was navigating upon. It was almost as if he thought he was going round a tennis ball when in fact he was on a flattened football. Not only would he be using incorrect distances but incorrect directions as well. [Smith 1986].

THE MEASUREMENT DIFFICULTY

The problem of measuring accurately an object the size of the earth is not an easy one yet the principle, first deduced by Eratosthenes around 230 BC, has remained the basis of all attempts until the advent of satellites. Although the method devised by Eratosthenes was based on the mathematics of a sphere it was later possible to modify it to apply also to shapes that were not quite true spheres.

Whatever one is measuring it is advantageous to determine by direct measurement as large a part of it as possible before resorting to extending a value by calculation. One has however to keep within the bounds of practicality. For example, if you wanted to measure the circumference of a football that would be done by putting a tape measure around it. If on the other hand it was required to measure the circumference of a large traffic circle it might be more practical to measure the length of an estimated quarter of it and multiply the result by four, or alternatively determine the diameter and multiply up by π. When the structure or figure involved becomes the size of the earth then a small fraction, say 1º, might be the more practical amount to measure and then multiply up by 360. This is in effect the basis of the method used.

WHY A GREAT CIRCLE?

As is well known, a line of longitude circles the earth and goes through both poles. Such a line is called a great circle of the earth. All lines of longitude are of that form but in latitude the only line that is a great circle and of comparable size is the equator. Thus to get the full circumference in as simple a way as possible it was necessary to measure (or calculate) the length of a circle or arc of longitude or of the equator. (This is rather an over simplification but can be accepted as the basis of what is required). As theory later developed so it became possible to use arcs that were not sections of great circles.

Assuming a spherical earth, Eratosthenes said that if you measured the linear distance between two points on a particular line of longitude (also called a meridian line as, for example, that of zero longitude through Greenwich), and were then able also to determine the angular distance subtended at the centre of the earth (see Figure 1) between the same two points then the radius and other parameters of the earth could be easily determined. Such an angle is not as inaccessible as it might at first appear as it can be found from star observations at each of the two points. The angle determined represented some fraction of the 360º circumference and its length was also known. A simple calculation would then give the circumference or radius.

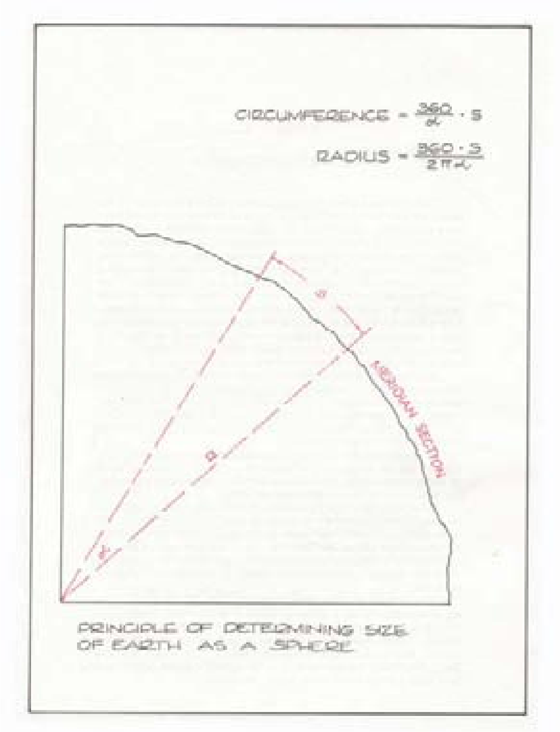

Figure 1. Principle of Determining Size of the Earth on a Sphere.

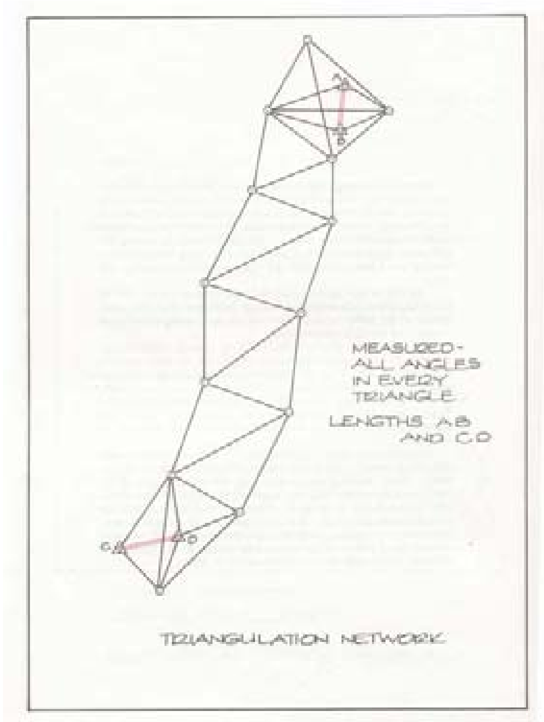

Figure 2. Principle of Triangulation

For example, if the angle was 6º then that would represent 6/360 or 1/60 of the circumference. If in turn the distance between the same two points was 600 km then the circumference would be 600 x 60 = 36 000 km. (of course they did not use kilometres at that time but the idea is the same).

Unfortunately there are many sources of error inherent in such observations, particularly in the angle and distance measurements. These in turn were functions of the inaccuracies of the equipment and methods of the time. Despite gradual improvements even by the late 15th century calculated values of the earth's size varied considerably and unfortunately the value selected by Columbus was incorrect by about 25%.

MEASURE LONG LINES

One of the difficulties in all the early measurements was that the linear distance required had to be physically measured from end to end by whatever method was felt the most appropriate at the time. Each distance had to be of the order of at least 60 miles (100 km). If much shorter distances only were used the accumulation of errors in the results would have been unacceptable. There were no tape measures then as we know them and the methods were pacing, knotted ropes, camel days journeys, the distance travelled by horsemen in a given time and variations on these.

As far as the angular value was concerned this could be found by observing the stars or the shadows of obelisks but in either case the results were crude.

THE ADVENT OF TRIANGULATION

It was not until the early 17th century that a more convenient method, triangulation, was developed in Holland and better measuring equipment became available. While it still kept to the basic principle of Eratosthenes for measuring a very long distance now an element of computation entered the method. It required a much shorter line to be measured as accurately as possible (a baseline) and the longer distance calculated by simple geometry. The angles were measured by instruments such as quadrants and later, theodolites.

Essentially the solution revolved around the fact that from a chain of triangulation it was possible to determine the distance between a point at each end of the chain. (Figures 2 and 9). [Smith 1986].

TRIANGULATION DEFINITIONS

Station point

These are marks at each observation position within a triangulation system. They can take a variety of forms as indicated on Section 3 Description in the Nomination.

Station witness marks

Around each station point it is general practice to have several witness marks each a few metres from the main station point and in different directions (see Figure 3). Then when it is required to recover a buried or hidden station point finding one or more of its witness marks can greatly assist in the full recovery.

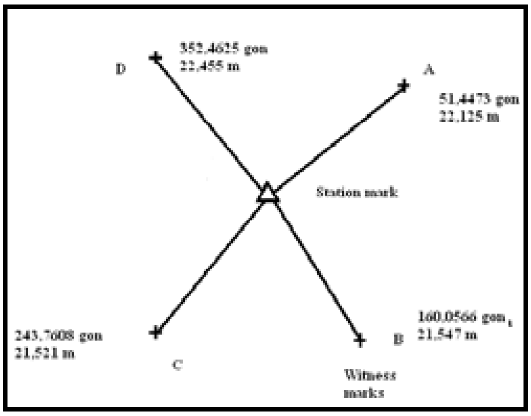

Figure 3. Station witness marks.

Offset station point

(Often called a satellite station until the advent of artificial satellites and possible confusion of terminology).

Observing with a theodolite to a point 40 kms away requires a very distinct target. This may be, for example, the spire or flagpole on a church as with point 11 at Tornio. The problem arises when it comes to setting up the theodolite at that point to sight back to where the theodolite was previously. It would obviously be impossible to set over the spire so an offset point would be used and be connected to the spire through several ancillary observations as shown in Figure 4.

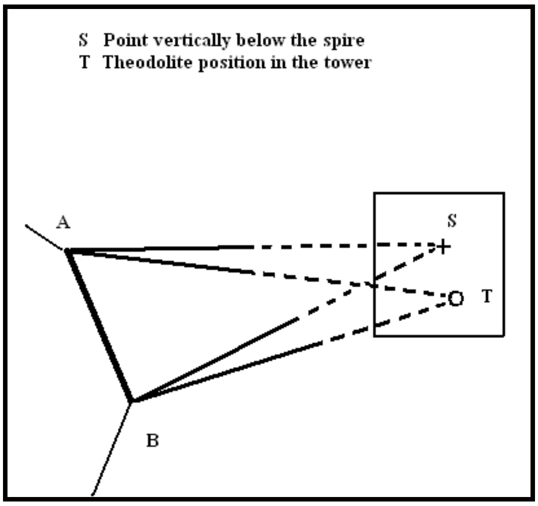

Figure 4. Principle of offset measurements.

A, B = two pegs say 10 m apart at ground level such that from each it is possible to see both the top of the spire (S) and a position in the tower (T) where it is possible to set the theodolite. By determining the coordinates of A and B in the survey system and measuring the angles at A and B to each of S and T it is possible to calculate the relative positions of S and T and the direction between them. From this information appropriate corrections can be applied to the observations to make them appear as if the theodolite were set over S rather than over T.

Base line

Triangulation in its simplest form is a chain of triangles spanning maybe several hundred kilometres of countryside with each of the sides of the triangles many kms in length. See Figure 2 above where AB and CD are baselines within the triangulation. Depending on the topography a side could be as much as a 100 kms long.

To determine the relative positions of each successive triangle corner (= station point) all the angles within the chain of triangles are measured as accurately as possible with, for example, a theodolite. So that coordinate geometry can be used it is also essential for at least one side (e.g. AB) to be measured to give scale to the whole chain and to allow the coordinates of each station point to be computed. Extra baselines such as CD in Figure 2 are often added to control the accumulation of errors. However if a side was 40 kms long it would have been impossible to measure it directly prior to the advent of electronic technology. There were though methods designed to measure lines of some 10-15 kms very accurately indeed (e.g. 2 or 3 mm per km. of length).

Base extension

To calculate a triangulation chain it is necessary to have a separate network of triangles to initially extend a measured baseline of 10 km to the 40 km. or more of a triangle side. Such a network is called a base extension and Figure 5 illustrates that used on the baseline at Elimä (Elimäki, Finland). There the measured baseline is AB and the required triangle side FG. By measuring all the angles in the figure the computation of FG is readily possible.

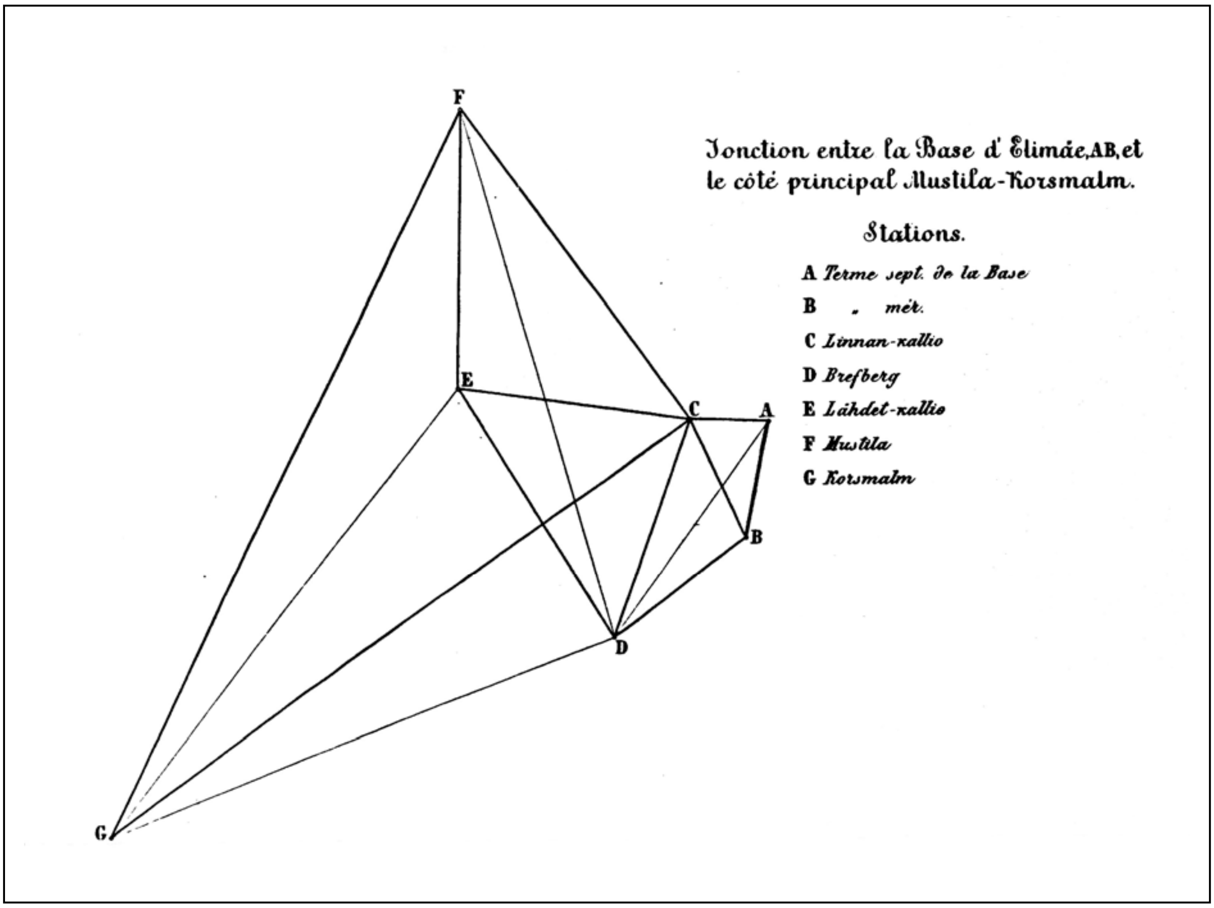

Figure 5. Elimä baseline

THE 'TRUE' SHAPE

Both theory and, as methods improved in sophistication, the practical results, suggested that the earth was probably not a true sphere after all but some slightly distorted shape. Ignoring the land elevations and sea bottom depressions around the world, sea level forms a sensible datum surface to which everything can be referred and can be treated mathematically.

Various long triangulation schemes were observed, particularly in different parts of France but by the first half of the 18th century also in Peru, Lapland, Italy, S. Africa and Austria. During the second half of that century and the early 19th century other arcs were observed in USA, Hungary, India, Sweden, England, Spain, Denmark and Germany.

The arcs in Peru and Lapland during the 1730s and 1740s settled the problem of the shape of the earth in that it was finally proved to be oblate (slightly flattened at the poles) rather than prolate (or elongated at the poles), as shown in Figures 6 and 7. The full name of this figure is an oblate spheroid. The difference from a true spherical earth is small, being only some 20 km between the maximum and minimum radii in a total of almost 6400 km. (i.e. only 0.3%), but nevertheless highly significant when navigating.

But that only solved half the problem. There was still the matter of an accurate value for the size of the earth and this was complicated by the fact that it was not now sufficient to do the calculations as if it were a perfect sphere.

THE SIZE OF A NON-SPHERICAL EARTH

To determine the dimensions of an oblate spheroid (or a prolate one if it had turned out to be that shape), requires the accurate determination of at least two long arcs as widely separated in latitude as possible. The various pre 19th century arcs in the list above were all useful but they did throw up difficulties not least of which was the effect of large mountain masses on the true position of a plumb bob, universally used to level observational instruments. It was proved during the 18th century survey work in Peru that if a plumb bob is hung in the vicinity of a large mountain mass then it is pulled (or attracted) slightly out of the vertical by that mass.

If the plumb bob is not vertical then any instrument that is itself made level (horizontal) by use of a plumb bob, will also be out of level by the same amount as the plumb bob is attracted. Thus the final value of the angular distance measured between the two arc ends would become distorted.

Increasingly as further arcs were measured and the accuracy improved so the uses to which the results could be put required yet greater accuracy. The vicious circle thus required further arcs to be measured. More uses were also found for the networks of triangles that resulted, not least the basis of accurate mapping of the countries concerned.

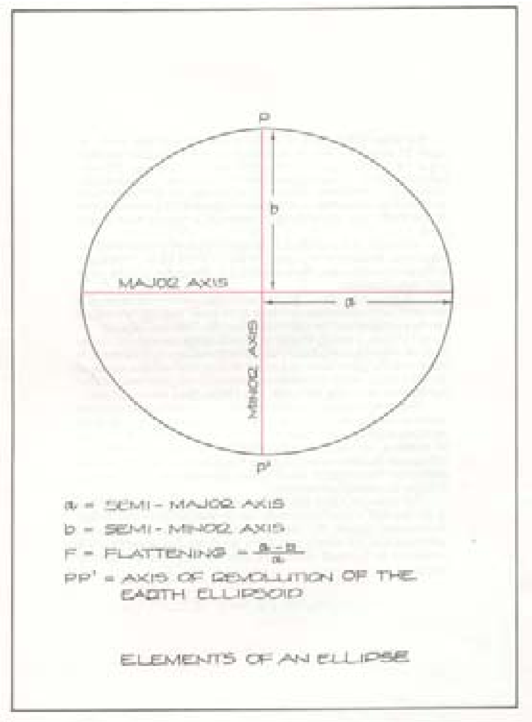

Figure 6. The elements of an ellipse

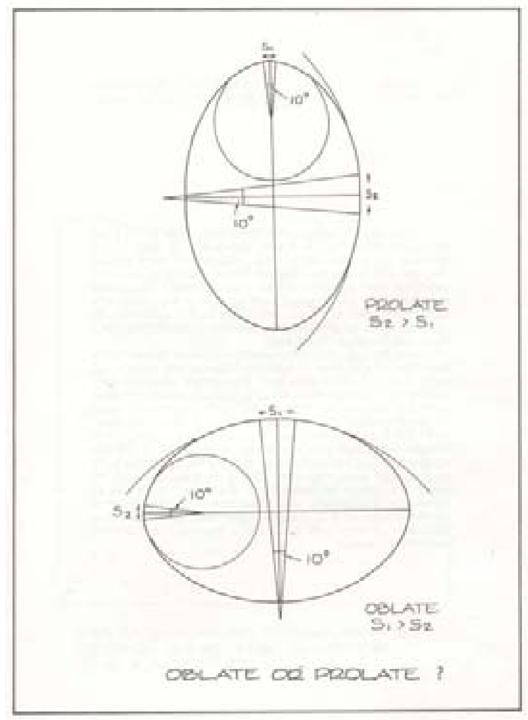

Figure 7. Oblate and prolate spheroid

MAUPERTUIS' ARC IN LAPLAND

The title *Lapland* although often used to describe this expedition is really a misnomer. While it represented the exotic landscape of the far north the survey was actually to the south of Lapland.

Polar Circle is a more apt description but *Lapland* is retained here because of its wide acceptance in English language publications and because of its brevity.

A year after Bouguer and La Condamine left France for Peru to measure an arc of a meridian as near to the Equator as possible a second expedition, under Pierre Maupertuis, left for Lapland. On the principle that if the oblate-prolate argument over the shape of the earth was to be settled once and for all, then it was necessary for an equatorial expedition to be balanced with another as near the Pole as possible.

Figure 8. The Arc measure of Maupertuis.

Unlike the Peru group where there was considerable friction between the members, maybe the terrain, length of time and conditions were enough to rouse anyone, the Lapland one appears to have been far more harmonious. Among the scientists involved was Anders Celsius (of thermometer fame).

They arrived in the vicinity of Tornio on 21st June 1736, taking two months to travel from Paris. After looking at alternatives they selected a stretch from near Tornio in the south to Kittis somewhat less than a degree further north over which to measure a triangulation scheme. This straddled the River Tornio between latitudes 65º 50' N and 66º 50' N. Not particularly mountainous but difficult to travel over and rough living conditions.

They measured a baseline on the frozen river surface using 8 fir rods each of 5 toises length (c 10 m) calibrated against an iron toise bar brought from Paris. During the measurement in mid-December the temperature fell to -37º R (-46º C). This, their only baseline, measured 7406,861 toises.

The angles of the 12 overlapping triangles were measured with a quadrant of 2 feet radius. The astronomical observations at Kittisvaara and Tornio were made with a zenith sector (see Figure 10) where the telescope was 9 feet long. From the various observations they determined the amplitude of the arc as 57'28.67" and its meridian length 55 023,47 toises. From which the length for 1º was found as 57 437,94 toises. When compared with other arcs of the period it was suggested that either the calculated length of the arc was too great by 200 toises or the amplitude too small by about 12 seconds of arc.

Investigations made in 1928 by Leinberg did in fact agree that various sources of error in Maupertuis' work could have amounted to about 12 seconds.

SVANBERG'S REMEASUREMENT

Because the results of Maupertuis, whilst verifying that the earth was oblate, were rather large in comparison to others of the same century elsewhere, the Swedish Royal Academy felt further investigation was necessary.

Svanberg and Öfverbom, the chief engineer at the Bureau of Surveys, spent April to October 1801 in this research and the selection of station points. They also added several extra points to both north and south to increase the arc by some 50%. Those in the south used some of the islands that Maupertuis had first thought of incorporating but which he found unsuitable.

Astronomical observations were to be taken at Mallörn, in the south- an island in the Gulf of Bothnia, and at Pahtavaara in the north.

For his baseline Svanberg found and used a mark near the south end of that of Maupertuis but not the north end. In terms of the toise of Peru they measured 7414,4919 t or some 8 t longer than that of Maupertuis.

The method of base measurement was similar in that it was done in winter starting on

22nd February 1802, and that for much of its length it was over ice. It was completed on 11th April 1802. They used 4 iron rods of 24.3 mm by 31.1 mm cross-section and a little more than 6 m long. They were fashioned such that they could slide together to bring their defining lines adjacent. Each bar was graduated against a 2 m standard brought from Paris for the purpose. Svanberg computed the length from Tornio to Kittisvaara to be some 25 toises less than that found by Maupertuis.

It should be noted that although the metric system had already been accepted by the time of Svanberg's measurements there was resistance and confusion at its introduction. Rather than measuring his angles to maybe 0,1 of a sexagesimal second Svanberg was using the centesimal second and quoting the very unrealistic 3 decimal places even though some of his very first triangles misclosed by nearly 9 centesimal seconds.

The angles and arc were computed by the method of Delambre to give an arc length of 180 827,68 m = 92 777,981 toises and amplitude of 1º37'19,56". Whence the length of 1º computes as about 57 196 toises compared with that of Maupertuis of 57 438 toises.

In comparing his result with that of Bouguer in Peru, Svanberg found the flattening of the earth figure as 1/329,246 whereas today the accepted figure is nearer 1/298,257.

Despite the improved equipment and greater length of arc used the inherent inaccuracies in the observations were still such as to mask much of the small variations from degree to degree that the scientists were endeavouring to resolve.

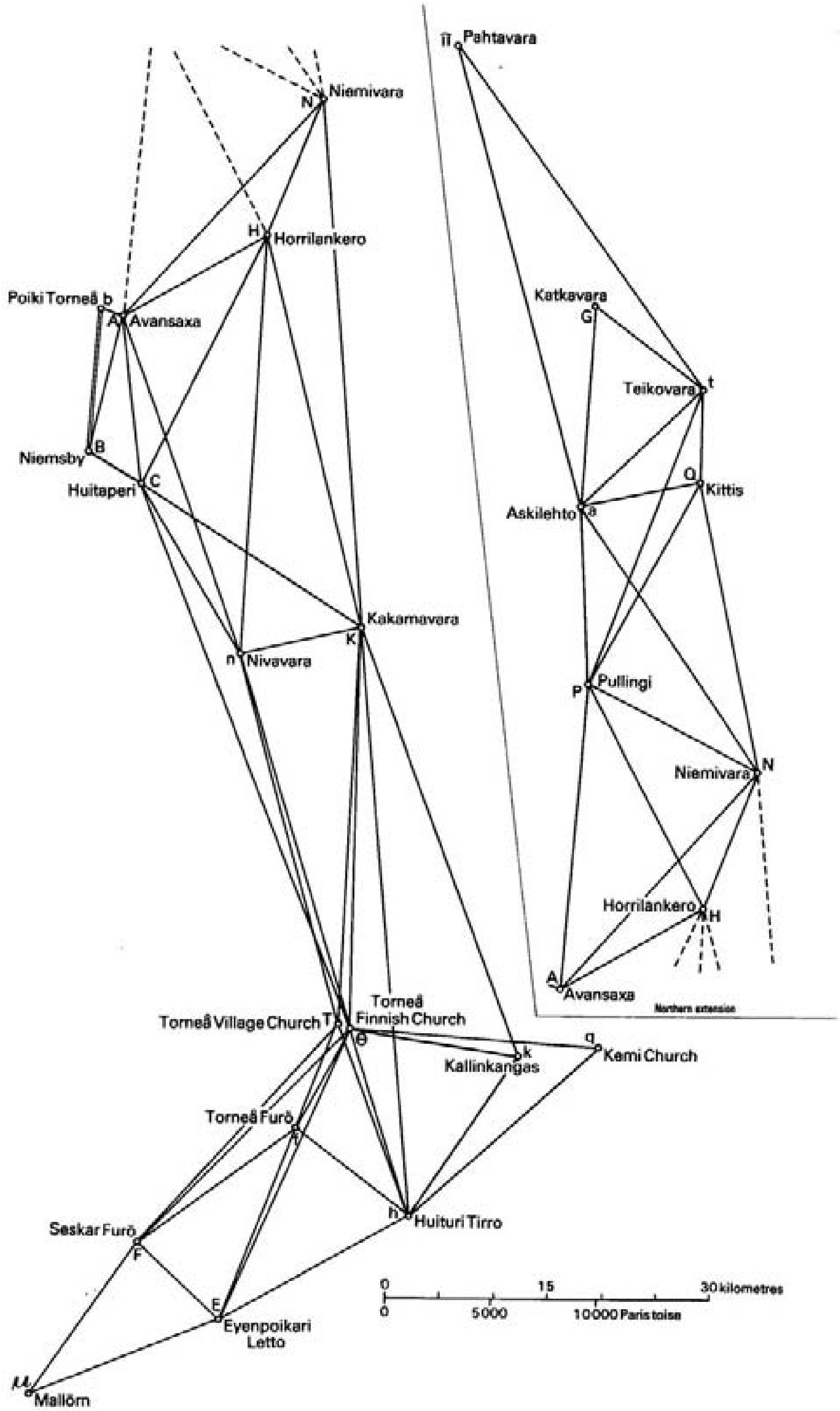

Figure 9. Svanberg´s network

THE FRENCH REVOLUTION

The seeds for the Struve Arc were sown by the Great French Revolution. Many traditional habits were replaced by new systems. Especially old measures were toppled by a new metric system. It was quite simple to stipulate that one quarter of a meridian would equal 10 million metres, but how long was the meridian? Among such measures at that time was the arc between Barcelona and Dunkerque, which, supplemented by measures in South America, yielded a prototype of the new unit, the legal Metre. However, it was based on quite inadequate measurements and calculations and within a matter of years the definition no longer held good.

The best possible result from the early arc measurements was derived by a Finnish astronomer H. J. Walbeck. He applied for the first time the method of least squares to compute the dimensions of the earth ellipsoid. However, a more reliable knowledge of the dimensions was still missing because of the limited number and limited length of measured arcs.

As another result from the French Revolution wars were raging all around Europe. The Napoleonic wars stretched from the North Cape to Cairo and from Moscow to Atlantic Ocean. The initial defeat of Napoleon resulted in the Vienna Conference but in the middle of negotiations Napoleon made a "come back" and war broke out again. When Napoleon was finally defeated the Vienna Conference reconvened and agreed in 1815 on the international boundaries in Europe and on the steps to be taken against the seeds of the revolution and against new uprisings.

At that time there was a general restlessness among the rulers in Europe. They did not trust a lasting peace and tried to be prepared for new wars. Mapping for such military purposes was a must and all steps to its promotion were advanced. [Härmälä 2000].

THE NEED FOR SUCH A MEASUREMENT

The lack of a proper framework for the topographic mapping was a problem at that time. Such a framework could be likened to a human skeleton upon which the flesh (or map information) is added. At the lower order a method called framework traversing was available but the higher order was more complicated. Astronomical observations were too difficult at the density needed in traversing, especially for the determinations of the longitude, which was still a very difficult

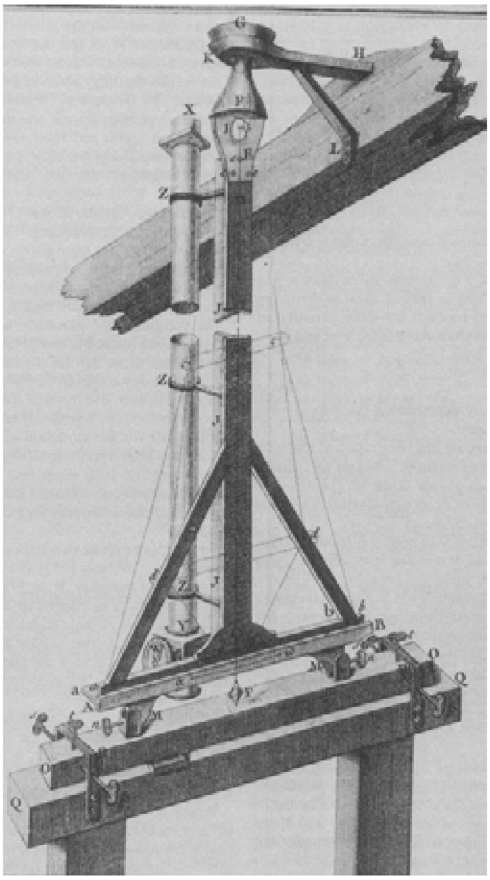

Figure 10. The Zenith sector

problem to solve. In addition, the coordinate system required a resolution to the uncertainty of earth ellipsoid dimensions.

Especially in Russia both needs were felt deeply; that of the fundamentals of geodetic surveys and that for suitable map grids. Many professors in mathematics attempted to foster new knowledge in these areas. Top military surveyors however were interested only in better mapping. It was Colonel Carl Tenner who managed to combine both needs in the triangulation work in Lithuania started in 1816. Astronomer Wilhelm Struve's proposal to the Czar of Russia in 1819 also combined both elements. Czar Alexander the First, after defeating Napoleon and entering Paris felt himself leader of European politics where science was fortunately among the top priorities.

Struve got all the resources he needed for his project.

The way was open for an arc measurement to develop the basis of a geodetic framework and to start the topographic mapping.

FIRST MOVES IN RUSSIA

At about the same time that the Peru and Lapland arcs were being measured Joseph de L´Isle published in 1737 [L'Isle 1737], a proposal for an arc to be measured through the Russian empire and embracing some 22º of meridian. He stated that ".this set of degrees when determined would display in an incontestable manner, if their variations were uniform, …would show whether different meridians have different curvatures." Surprisingly the Empress Anne of Russia was not frightened by such a vast proposal and gave it her backing to contribute to the progress of science.

Unfortunately in 1739, after de L´Isle got as far in his triangulation as measuring a base on the ice from Peterhof Castle in Kronstad to Doubni Castle on the island of Retusri, and connecting the base to several points by triangulation, a journey to Siberia in 1740-41 interrupted his work and it was never restarted.

At that time the metre had yet to be developed and the base had actually been measured at about 13,5 verstes, an old Russian unit of approximately 1,067 km per verste (or a base length of 14,4 km). The measurement itself was by wooden bars of known length placed end to end. Nothing was published on this work but in 1844 Otto Struve, son of F.G.W. Struve, did come across de L´Isle's manuscript in the Paris Observatory archives [Butterfield 1906]. For his angles de L´Isle talked of using a 30º sector of 12-15 ft radius (see Figure 10) and a quadrant of 2-3 ft radius (see Figure 11).

Nothing more materialised in that region until 1814 when B.A. von Lindenau, Director of the Seeberg Observatory, an aide-de-camp to the Grand-Duc of Weimar, proposed to Prince Wolkonsky, Chef de l'Etat-Major Imperial, the measure of an arc of meridian (or section of a line of longitude) to follow the western provinces of Russia south from the White Sea. He presented the proposal to the Russian authorities. This did not progress because of a disagreement over which instruments - German or Russian- should be used. Struve's opinion however was that in any case it was not a good site for well-conditioned triangulation.

STRUVE AND HIS COLLEAGUES

The early 19th century saw the commencement of a very long arc through India by William Lambton. On the death of Lambton in 1823 it was continued to its completion in the 1840s by George Everest so that it extended from the southern tip of India to the foothills of the Himalayas. [Smith 1999a].

Around 1812 F.G.W. Struve, Professor of Mathematics and Astronomy at the University of Dorpat, was put in charge of a trigonometrical survey in Livonia. This was controlled by a baseline on the ice of Lake Werz-Jerw, measured in 1819. [Mets 2002a].

During 1820 Struve assisted Gauss in the base measure by Schumacher made near Braack with his new Repsold equipment.

This work enabled Struve to interest officials in the idea of an arc of about 3½º between Gogland, an island in the Gulf of Finland, and Jacobstadt to the south. After getting the resources he was able to observe the arc between 1821 and 1831.

During more or less the same period (1816-1828) Carl Tenner was doing similar work further south in Lithuania but at that stage he was operating quite independently from Struve.

Once he had completed his early surveys, Struve was keen to extend the measurements further north and south so that a very long line would result and could be the basis of a sound set of values for the earth parameters as well as having other uses. He would have been aware of the work at that time in India [Smith 1999], and that it would be an ideal partner to anything he did through Russia, to determine the earth's parameters. (As indicated above, one arc on its own is insufficient to determine the parameters of an oblate spheroid).

SELECTION OF THE ROUTE

It is little surprise, since Struve worked at Dorpat University, that he decided any extensions of his surveys should follow, as nearly as possible, the line of longitude (meridian) through Dorpat Observatory at about 27º East of Greenwich. Looking at this line on a map it was clear that some work had already been done in its vicinity in the far north (by Maupertuis 1736-37; and by Svanberg 1802-03) from the northern end of the Gulf of Bothnia well into the Arctic Circle. Here was an opportunity to connect to that work and further extend the line. At the same time it became clear that Tenner was working more or less along the same meridian towards the south. While Struve could envisage the northward extension, Tenner similarly noticed how there could be a southern extension as far as the Black Sea. Thus the elements were present for an arc that stretched from Fuglenaes near Hammerfest in the far north over some 2800 km (1750 miles) to Staro-Nekrassowka near Ismail in the south over 25º of latitude. Today the line stretches through ten different countries.

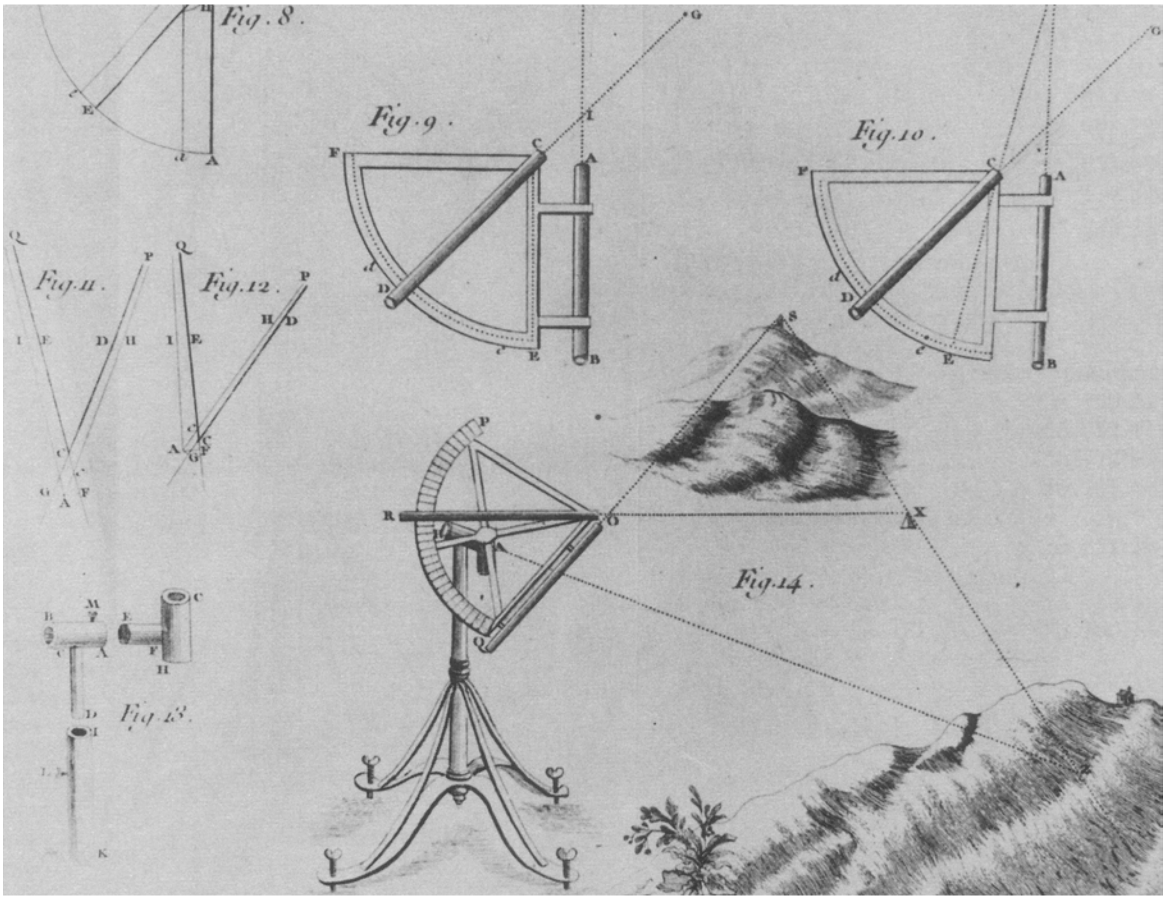

Figure 11. Use of the quadrant.

It was quite natural that both Struve and Tenner assumed the astronomical positions of Dorpat (Tartu) and Vilna (Vilnius) respectively, as zero meridians of their independent surveys. Luckily, those were close enough to enable a trigonometrical link. Then the observed latitudes and azimuths allowed calculation of the longitudes to the other points in relation to the zero meridians. In fact Dorpat was selected as the origin in both N-S and E-W. for all calculations.

THE DAUNTING TASK

To even contemplate such a huge scheme of extensions and collaborations was a daunting task in itself. Such an arc would however:

(a) build upon the previous schemes in Peru and Lapland which basically set out to prove the shape of the earth but the equipment for which was still relatively crude,

(b) allow computation of accurate figures for the earth dimensions,

(c) be the first arc to feature in the Russian Empire,

(d) be the longest, and most northerly extended, arc at that time,

(e) complement both the 1792-1825 meridian arc through France, Spain and England by Delambre, Mechain, Arago, Biot, Kater and others; and the l821-1823 arc of 15º along the 45th parallel of latitude across France, Austria and Italy by Brousseaud, Carlini and Plana.

In the 1860s A.R. Clarke, made very extensive inter-comparisons of arcs around the world in an endeavour to get the best possible overall results for the earth's dimensions. The Struve arc featured prominently in his calculations and was the longest of the six he used.

Further extensions in the 20th century have resulted in the "Struve" arc now theoretically reaching from near North Cape in Norway to Port Elizabeth in S. Africa. It was 1954 when two quite separate arcs - that by Struve and that started by Sir David Gill in 1879 in South Africa which gradually worked its way northwards - made a link up feasible.

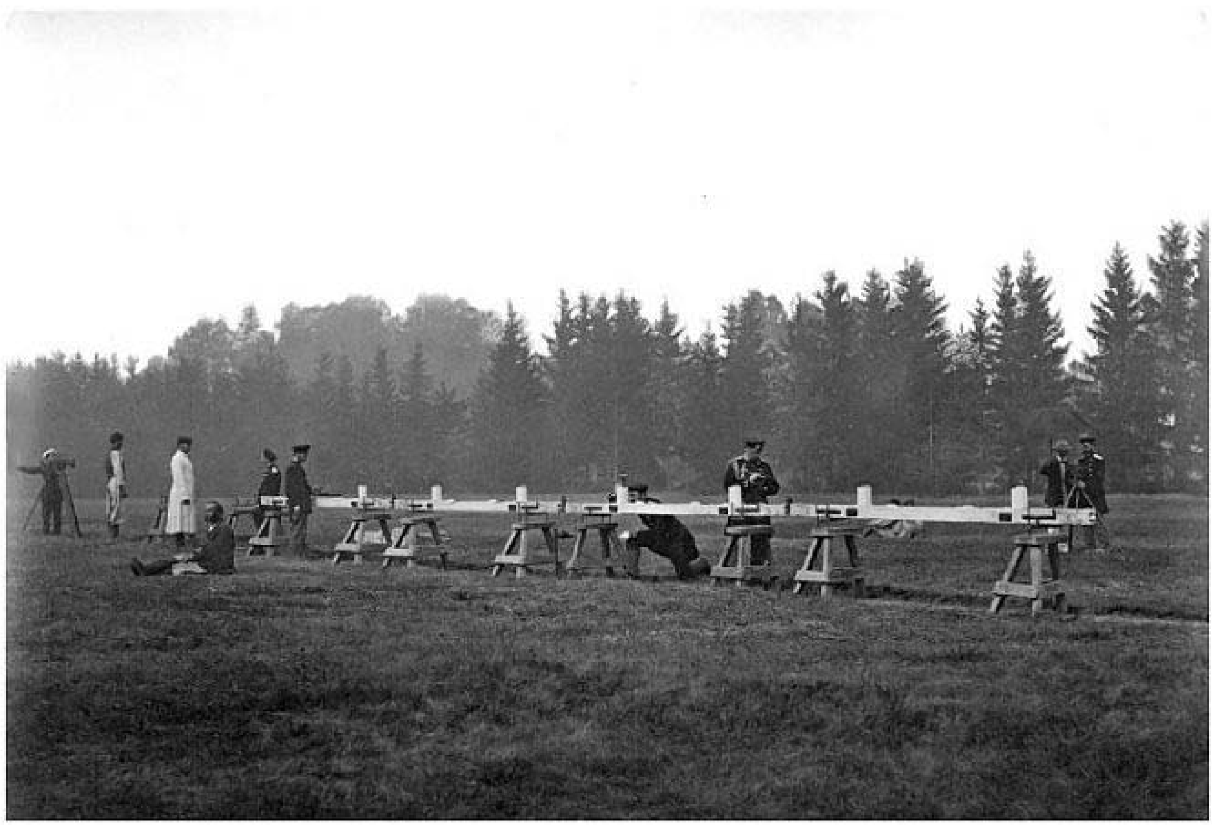

Figure 12. The measurement of baseline, *(Picture is a courtesy of Museum of Pulkova)*

Years	**Leader**	**Latitude**	**Section of arc**	**Baselines**	**Other triangulations**
1845 – 1850	**HANSTEEN**	70º 40' 68º 54'	Fuglenaes, Hammerfest Norway Kautokeino	1850 Alten base	
1845 – 1852	**SELANDER**	68º 54' 65º 50'	Kautokeino Sweden Finland Tornea	1851 Över-Tornea base	1736-37 Maupertuis 1802-03 Svanberg
1830 – 1851	**STRUVE**	65º 50' 60º 05'	Tornea Finland Gögland	1845 Uleaborg base 1844 Elimä base	1802-03 Svanberg
1821 – 1831	**STRUVE**	60º 05' 56º 30'	Gögland Baltic Jacobstadt	1827 Simonis base	1816-19 Livland Survey based on Dorpat
1816 – 1828	**TENNER**	56º 30' 52º 03'	Jacobstadt Lithuania Belin	1820 Ponedeli base 1827 Ossownitza base	1816-51 Trig. Survey of W. Russian Territories based on Vilna
1835 – 1840	**TENNER**	52º 03' 48º 45'	Belin Podolia &Volynia Dnestre River	1838 Staro-Konstantinow base	1816-51 Trig. Survey of W. Russian Territories based on Vilna
1846 – 1851	**TENNER**	48º 45' 45º 20'	Dnestre River Bessarabia Staro-Nekrassowka, Ismail	1848 Romankautzi base 1852 Taschbunar base	1816-51 Trig. Survey of W. Russian Territories based on Vilna

Table 1. Progress of the fieldwork.

THE FIELDWORK

Bjørn Harsson, speaking at the FIG Congress in Melbourne in 1994 [Harsson 1994] summarised Struve's [Struve 1860] reported division of work on the arc in four phases totalling seven sections. Diagrammatically the various phases of the arc measurement are shown above. Details of the fieldwork are given on pages 19-20.

INSTRUMENTATION

Struve used a universal instrument (theodolite) by Reichenbach of Munich, which had a 13-inch diameter horizontal circle and 11 inch vertical circle. These were graduated to 5' (= minutes of arc) and read directly by verniers to 4" (= seconds of arc).

Tenner used a variety of seven instruments by a range of different makers. There were two repeating circles, one of 13 inches diameter by Baumann, which read to 4" by vernier, and the other 14,3 inches by Troughton reading by vernier to 10". A 12 inch diameter terrestrial repetition theodolite by Reichenbach read by vernier to 4" an 8 inch astronomical repetition theodolite by Ertel reading to 10"; a repeating theodolite of 10 inches made in the Etat-major and reading to 5"; and two instruments by Ertel. The first two of these instruments gave inclined angles whilst the other five used by Tenner and that by Struve gave horizontal angles direct. [Butterfield 1906].

UNITS AND STANDARDS OF LENGTH

Although at the time of the surveys, the metric system was well established, the base measurements were recorded in two different units of length. Struve used the old French "toise" (approx. 1,949 m) because his basic standard had come from France. Meanwhile Tenner used the Russian unit the "Sajen" (approx. 2,134 m) because his basic standard had been built in St Petersburg based on an English "foot", as in the 18th century 1 sajen was defined equal to 7 English feet. The two units first "met" or came together on the Struve arc of the meridian. By 1830 Struve and Tenner had solved the problem of converting sajens into toises through careful examinations of their measuring bars and the respective standards, and Struve was able to present further results in toises. His final table of the length of the arc segments is computed in those units, probably for the last time in history and probably also as a sign of the merits of Frenchmen in measuring the earth.

Some complications later occurred when trying to determine the best conversion factor for relating the toise to the modern metre. Various factors will be found ranging from 1,949 to 1,949 087. Of course, with the long distances that occur in this project the last digits can make a significant difference.

The standard unit used was the toise of Paris, which was the same as the toise of Peru. Copies were specially commissioned by Struve and Bessel and constructed by Fortin. From his copy Struve had two field standards made each of about 2 toise or 1728 lignes long. (1 ligne = 1/12 inch). Tenner on the other hand used a standard of 945 lignes, which equates to the Russian sajène or 1,0946 toise. During 1850 to 1853 19 different standards were inter-compared at Pulkovo. Thus the relationships become complicated.

That used on the baselines of Simonis, Elimä and Uleaborg was of 1728,01249 lignes of the Fortin toise at 13ºR. For the bases at Alten, Öfver Tornea and Taschbunar the standard was of 1727,99440 lignes. For the Romankautzi base the standard was of 1728,01991 lignes. The value of Tenner’s standard, used for the bases at Ponedeli, Ossownitza and Staro-Konstantinow was of 945,75779 lignes. [Struve 1860].

BASELINES

Sprinkled among the 258 principal triangles were ten baselines, three of which were measured with Tenner's apparatus and seven with that of Struve. The Struve equipment consisted of four wrought iron bars each of 2 toise in length. One end of each bar had a small cylinder with slightly rounded end; the other end of each had a contact lever, which was pivoted to the bar. Two thermometers were set into holes in the bars and the bars were each set in boxes from which their ends protruded. Seven of the baselines were measured using this equipment and Struve estimated the probable errors of each to be around one ppm (parts per million or 1 mm per km).

The other three baselines were measured by equipment devised by Tenner. Here the bars were of forged iron 2 sajènes long. One end of each bar was fixed and the other free to move. At this latter end was a sliding scale that could be used to determine the distance between consecutive bars.

Struve estimated the probable errors of Tenner's apparatus to be around 3ppm. With a single exception, all the baselines were measured in one direction only, thus control over the lengths of sides connecting successive arc segments was essential.

The last column of Table 2 gives the quoted accuracy when computing from one baseline to the next which is not the same as the accuracies of the individual baselines as noted above.

Baselines

Date	Tri-angle	Country	Latitude	Name	Reduced length Toises / Metres	Reduced to	Accuracy between bases
1850	252	Norway	69º55'	Alten*	1154,744 2250,67	Arctic Ocean	1/395 991
1851	230	Finland	66º22'	Öfver-Tornea*	1519,839 2962,27	Gulf of Bothnia	1/29 964
1845	216/ 217	Finland	65º00'	Uleaborg*	1505,317 2933,96	Gulf of Bothnia	1/32 594
1844	162	Finland	60º50'	Elimä*	1348,746 2628,80	Gulf of Finland	
1827	150	Estonia	59º02'	Simonis*	2315,133 4512,35	Gulf of Riga	1/58 502
1820	117	Lithuania	55º58'	Ponedeli**	6055,162 11801,92	Gulf of Riga	1/35 130
1827	79	Belarus	52º14'	Ossownitza**	5719,643 11147,97	Gulf of Riga	1/26 104
1838	53x	Ukraine	49º42'	Staro-Konstantinow**	4563,972 8895,49	Gulf of Riga	1/28 211
1848	42	Ukraine	48º30'	Romankautzi*	2910,094 5671,97	Gulf of Riga	1/85 639
1849 1852	6/ 7	Ukraine	45º35'	Taschbunar*	2770,317 5399,33 2770,246 5399,40	Gulf of Riga	

Table 2. Baselines (for arc metrology)

Conversion factor 1 toise = 1,949 067 metres
* = with Struve apparatus
** = with Tenner apparatus
NB Taschbunar was measured twice

REFERENCE MERIDIAN

Struve was working in Dorpat (now Tartu) Observatory and so it was logical to select the meridian line through that place as a reference line. It was taken as the start (datum) point in both latitude and longitude. Distances were calculated N and S of Dorpat with Dorpat as 0, reaching 710 000 toises to the north and 740 000 toises to the south. Details are given in [Smith 2002] of the location of the reference point under the centre of the cupola of the observatory. The point was relocated from Struve's original measurements and is now marked with a 12 mm bronze marker and a commemorative plaque unveiled in 2002.

RESULTS

The complete summary and description of all the work and results fill 961 pages in [Struve 1860] together with maps.

COORDINATES ON THE STRUVE ARC

Due to his incurable illness diagnosed at the beginning of 1858, Struve never managed to publish the 3rd volume of his "Arc du meridien…". A full account of the astronomic operations, final results, a critical evaluation of the world arc measurements and derivation of a series of related earth figure parameters would have been contained there. Perhaps, a full list of geographic coordinates of all the arc stations was also kept in mind for use by the Russian

Army General Headquarters that shared the arc field operations from the very beginning in 1816. Such a full list was not computed until 1926.

Before that time some Russian regional nets did include Struve arc stations, with subsequent derivation of their coordinates. For instance, in 1892 the Head of the Russian Survey of Finland Lieut. Gen. Järnefelt published a list of geographic coordinates of 91 stations of the northern part of the Struve arc from Gogland (Mäki-päälys) to the Norwegian border (Stuor-oivi). The values were computed on the 1819 Walbeck ellipsoid with longitudes related to Dorpat meridian. In 1926 a vast list of coordinates of the Russian 1st order triangulation points was published, including Struve arc Russian stations south of Kaakamavaara (near Tornio) to Izmail, that resulted from computation on the 1841 Bessel ellipsoid, the longitudes being related to Pulkovo. Both the Lists were in the Proceedings of the Russian Military Topographers Corp (in Russian). Since then, due to the collapse of the Russian Empire and subsequent political changes in Eastern Europe, there have been no other computations for the entire arc although there have been separate calculations within national borders (Latvia, Finland, Norway, Poland, Romania). [Zhongolovich 1956].

Observations for latitude and azimuth were made at 13 selected stations 3 of these were in Scandinavia and the other 10 in the Russian Empire states. This gave 12 arcs that could be computed separately. These varied from 1º 22' to 2º 54' in length (see Table 3).

From these the length of 1º was determined for each of the 12 arcs and these varied from 57252 t in the far north to 57068 t in the far south but there were some inconsistencies in between (see Table 6). Using seven different divisions there was a more regular decreasing pattern between similar extreme values. (A decrease as one moves from north to south indicated an oblate rather than a prolate shape for the earth.)

Azimuths

Date	Country	Astronomical Latitude	From	To	Azimuth
1850	Norway	70º40'11,2"	Fuglenaes	Jedki	220º30'20,5"
1850	Finland	68º40'58,4"	Stuor-oivi	Pajtas-vaara	168º22'59,4"
1845 1851	Finland	65º49'44,6"	Neder-Tornea church	Kaakama-vaara	3º01'30,9"
1852	Finland	62º38'05,2"	Kilpi-mäki	Silmut-mäki	274º48'04,3"
1843	Russia	60º04'29,2"	E on Mäki-päälys	Ristisaari	342º10'10,9"
1826	Russia	60º04'29,2"	E on Mäki-päälys	Belfry Halljall	209º09'17,3"
1826-1828	Estonia	58º22'47,6"	Centre Observatory Tower Dorpat	Kersel	337º36'39,6"
1826	Latvia	56º30'05,0"	Jacobstadt, astro point	Dabors-kalns	312º22'02,4"
1827, 1855	Lithuania	54º39'04,2"	Nemesch	Meschkanzi	359º59'57,1"
1827, 1853	Belarus	52º02'42,2"	Belin	Leskowitschi	61º44'04,8"
1837	Ukraine	50º05'50,0"	Kremenetz	Gurniki	18º07'17,4"
1838, 1852	Ukraine	48º45'03,0"	Ssuprunkowzi	Karatschkowzi	311º35'47,6"
1848	Moldova	47º01'25,0"	Wodolui	Dschamana	157º41'27,1"
1848, 1852	Ukraine	45º20'02,8"	Staro-Nekrassowka	Belfry Ismail	270º56'05,5"

Table 3. Azimuths for astronomical positioning and orientation.

The results of the 1816-1855 arc measurements were first published by W. Struve in 1857 (unfortunately, without astronomy and the historical preface), then in 1860 (in full) each edition in French. In 1861 an identical Russian edition was issued and some selected chapters of this were republished in 1957.

In these Struve's definitive conclusion was that the overall length of the meridian arc was 1447 787 toises (= 2 821 833 m) for 25º 20' 08,29". However, Struve became ill and could not complete the compilation of astronomical results and derivation of the definitive values of the earth's parameters "a" and "f" (Figure 6). He only derived preliminary values of these combining his results with those of Bessel and Everest, resulting in semi-major axis (a) of 3272539 toises and flattening (f) of 1:294.73

He did however make other calculations with varied results.

Others since, including Bessel (from 1834 to 1841) and Clarke (1858 and 1861), and many others afterwards all used Struve's latitudes and arc section lengths to combine with other arcs around the world.

ACCURACY

Among the various figures Struve gave were those for a measure of the accuracy achieved in the various sections and values for the probable error of each of the 12 sections between successive astronomical stations. This gave the following list and indicates the overall high accuracy of around 1/200 000 (i.e. 5 mm per km) achieved overall [Struve 1860] v.2 p 210:

Astronomical points

Between stations	Distance (toises)	p.e. (toises)	Fractional
Fuglenaes - Stuor-oivi	113 753,91	±1,78	1/ 63 908
Stuor-oivi - Tornea	163 221,90	1,69	1/ 96 581
Tornea - Kilpi-mäki	182 794,30	1,67	1/108 162
Kilpi-mäki - Hogland (Z)	145 713,57	1,07	1/136 181
Hogland (Z) - Dorpat	97 538,65	0,50	1/195 773
Dorpat - Jacobstadt	107 280,56	0,68	1/157 765
Jacobstadt - Nemesch	105 730,88	0,93	1/113 689
Nemesch - Belin	148 809,52	1,43	1/104 063
Belin - Kremenetz	111 219,01	1,01	1/110 118
Kremenetz - Ssuprunkowzi	76 751,39	0,71	1/108 100
Ssuprunkowzi - Wodolui	98 557,99	1,25	1/ 78 846
Wodolui - Staro-Nekrassowka	96 415,14	0,66	1/146 083
Overall	**1 447 786,78**	**6,23**	**1/232 390**

Table 4. Distances and accuracies between astronomical points.

SUMMARY

1830 End of phase one:
There was a complete meridian arc from Hogland in the Gulf of Finland (latitude 60º 05') to Belin (latitude 52' 02') = 8º 03' extent.

1844 End of phase two.
There was a complete arc from Tornea to the Dnestre river (latitude 48º 45')

1851 End of phase three.
There was a complete arc from Fuglenaes to Staro-Nekrassowka
except for the need to add some supplementary data and re-observe various suspect stations, which took place during the last phase.

A summary of the whole arc is given in [Harsson 1994] thus:

Northern terminal Hammerfest (Fuglenaes) latitude	70º 40' 11,23"	
Southern terminal Ismail (Staro-Nekrassowka)	45º 20' 02,94"	
Difference in geographic latitude	25º 20' 08,29"	

Difference in	toises	1 447 786,783 ± 6,226
	Kms	2 821 833,711*

Origin of the meridian arc located in Dorpat latitude	58º 22' 47,56"	± 0,05"
Time difference between Greenwich and Dorpat	1h 46m 53,536s	± 0,066s
The longitude of Dorpat related to Greenwich	26º 43' 23,04"	

* Value in kms will vary slightly according to conversion factor used.

Meridian arc lengths.

Stations	Arc in toises	Arc in metres	Arc in feet	Latitude
Fuglenaes				70º40'11"
	113 754	221 714	727 403	
Stuor-oivi				68º40'58"
	163 222	318 130	1 043 728	
Tornea				65º49'45"
	182 794	356 278	1 168 884	
Kilpi-Mäki				62º38'05"
	146 359	285 264	935 900	
Mäki-päällys				60º04'29"
	96 893	188 850	619 584	
Dorpat				58º22'48"
	107 281	209 097	686 009	
Jacobstadt				56º30'05"
	105 731	206 077	676 100	
Nemesch				54º39'04"
	148 810	290 040	951 567	
Belin				52º02'42"
	111 219	216 773	711 194	
Krementz				50º05'50"
	76 751	149 594	490 789	
Ssuprunkowzi				48º45'03"
	98 558	192 096	630 232	
Wodolui				47º01'25"
	96 415	187 920	616 530	
Staro-Nekrassowka				45º20'03"
Totals	**1 447 787**	**2 821 833**	**9 257 921**	**25º20'08"**

Table 5. Meridian arc lengths.

Toise values from Struve records [Kaptjug 2000].
Foot values from [Clarke 1880] pp 34-35.
Metre values by use of conversion factor K = 1,949 067 (from [Zhongolovich 1956] cited in [Kaptjug 2000]).
Note that Vassiljev in 1994 appears to have used K=1,949 and hence all his metre values are less than those above.
In all the toise-metre conversions the last three decimal places make noticeable differences. These digits are found variously as 087, 081, 067 (0668) or 061.

SUBSEQUENT USE

The amount of work is not the only merit. Taking the instrument and observation techniques of that time into account the achieved accuracy was amazing. Co-ordinate transformations between some Struve points and coinciding new points measured applying the best methods over one century later, have revealed an unexpected quality. The discrepancies were of the order of some centimetres, maybe one or two decimetres. One lost Struve point was found when measured from a nearby new triangulation point. It was about one decimetre from the computed site. Perhaps the accuracy of the methods of the time deserves admiration.

Length of 1º.

Stations	**Arc in metres**	**Amplitude of arc**	**Length of 1º (km)**
Fuglenaes			
	221 714	1º59'12,8"	111,589
Stuor-oivi			
	318 130	2º51'13,8"	111,475
Tornea			
	356 278	3º11'39,4"	111,536
Kilpi-Mäki			
	285 264	2º33'36,0"	111,431
Maki-päällys			
	188 850	1º41'41,6"	111,423
Dorpat			
	209 097	1º52'42,6"	111,311
Jacobstadt			
	206 077	1º51'01,2"	111,373
Nemesch			
	290 040	2º36'22,0"	111,292
Belin			
	216 773	1º56'52,2"	111,289
Krementz			
	149 594	1º20'47,0"	111,108
Ssuprunkowzi			
	192 096	1º43'38,0"	111,217
Wodolui			
	187 920	1º41'22,1"	111,230
Staro-Nekrassowka			

Table 6. Length of 1º.

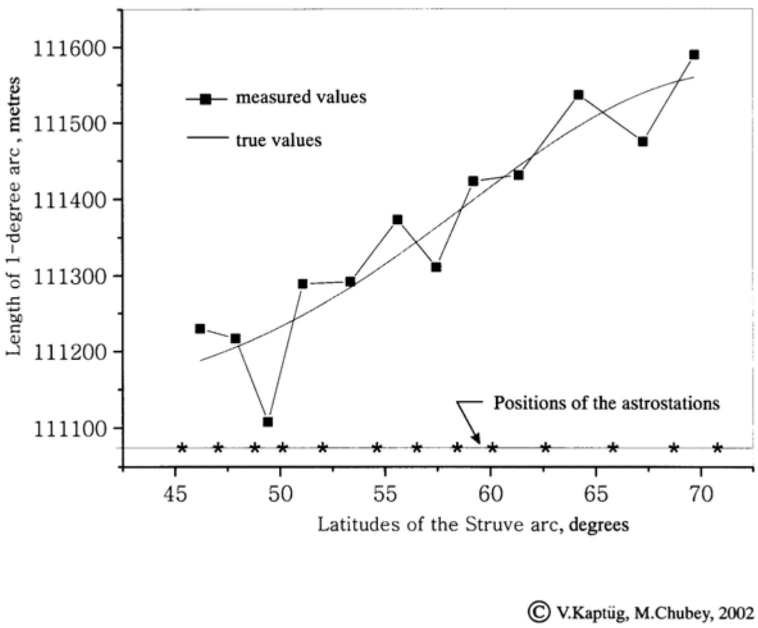

Figure 13. Length of 1º on different latitudes of Struve Geodetic Arc.

Another remarkable item of the Struve arc is the monumentation of the stations. In Finland many were marked on the solid rock by drilling a hole. The hole was filled with lead and on the top of the lead was a plate of brass. Veriö [Veriö 1994] elaborated this point saying that nearly all stations between Hogland and Tornio were marked with small copper plates, which were soldered with lead into 5-7 cm deep holes drilled in the rock or big stones. In the course of time most of the plates have disappeared. In fact most of them were found missing already in the 1890s. Later the lead has been dug out, maybe to be made into shot for the hunters. However, nobody has been able to take away the holes. Unfortunately, Struve did not leave ground markers to mark the positions of his stations between Gögland and Jacobstadt (Ekabpils, Latvia), except for the two terminals. The monumentation south of Jacobstadt belongs exclusively to the merits of Tenner.

The Struve chain brought several benefits. The long and accurate chain gave a fine addition to the determination of the spheroid but it also had plenty of indirect influence. The principles of the work were published in all details and this made the arc a good example for others to adopt. Even the personal contacts made over the forty years were important. For instance, Struve had an influence on the measurement of an arc along the line of latitude 52º carried out in the second half of the century. It was Tenner who asked Bessel to derive new dimensions of the earth incorporating use of the Russian arc.

Many chains were measured in different continents in subsequent years. Some results of these activities can be seen in the development of the computed dimensions of the earth.

Parameters of the Earth

Year Name	a (in m)	F	Meridian Quadrant (in m)
1819 Walbeck	6 376 896	1:302,8	10 000 091
1841 Bessel	6 377 397	1:299,15	10 000 966
1853 Struve	6 378 398	1:294,73	10 002 174
1880 Clarke	6 378 249	1:293,5	10 001 869
1924 International	6 378. 388	1:297	10 002 288
1935 Krassowsky	6 378 180	1:298,9	10 002 069
1967 International	6 378 160	1:298,2471	10 001 986

Table 7. Earth parameters.

Where a = semi-major axis, b = semi-minor axis and flattening f = (a-b)/a, (see Figure 6)

Table 7 gives just a small sample of generally used values. Very clearly the mutual agreement has become better since the publishing of the Struve arc and succeeding measurements. This has given a good start to uniform mapping, its framework and the map projection systems.

Indirectly it has also helped the spread of the metric system as it became more generally accepted in principle at the international agreement in the year 1875. It is true, the length of the basic unit no longer depends on the determination of the earth dimensions but in the 19th century it was the chosen way.

Because of the number of countries it passes through the Struve arc has had a remarkable effect on the framework for mapping. Strong chains with permanent marking and good documentation have ever since belonged to the basic work in many countries. New base lines and astronomical stations were distributed along the Struve arc triangulation chain and made it an inseparable part of developing a traditional framework for European geodesy and mapping. These principles have then been followed for nearly 150 years until the Global Positioning System (GPS) has now completely changed the methods.

The Struve arc has not only served triangulations as an example. Its points have been the starting points to many new triangulations and traverses in the intervening period. Up to the 1960s the Struve arc was the only connection of coordinates between South and North Finland. An additional advantage has been the careful trigonometric levelling along the points in the chain. [Härmälä 2000]

Data from this arc was used in 1942 by Izotov and Krassovsky in their ellipsoid calculation and as recently as 1956 in the new determination of the figure of the earth by Chovitz and Fischer [Chovitz and Fischer 1956; Army Map Service 1956]. Norwegian geodesists repeated the astronomical observations at Fuglenaes in 1928 with Hans Jelstrup and in 1950 with Yngvar Schiott. There was good agreement with a variation in latitude of less than 6m.

LATER RESEARCH

In 1861 the Prussian General and geodesist Johann Jacob Baeyer (1794-1885) proposed plans for arc measurements covering Europe. This almost immediately led to the Mitteleuropäische Gradmessung, which soon became renamed as Europäische Gradmessung and which finally became the Association Internationale de Géodésie (IAG) of today.

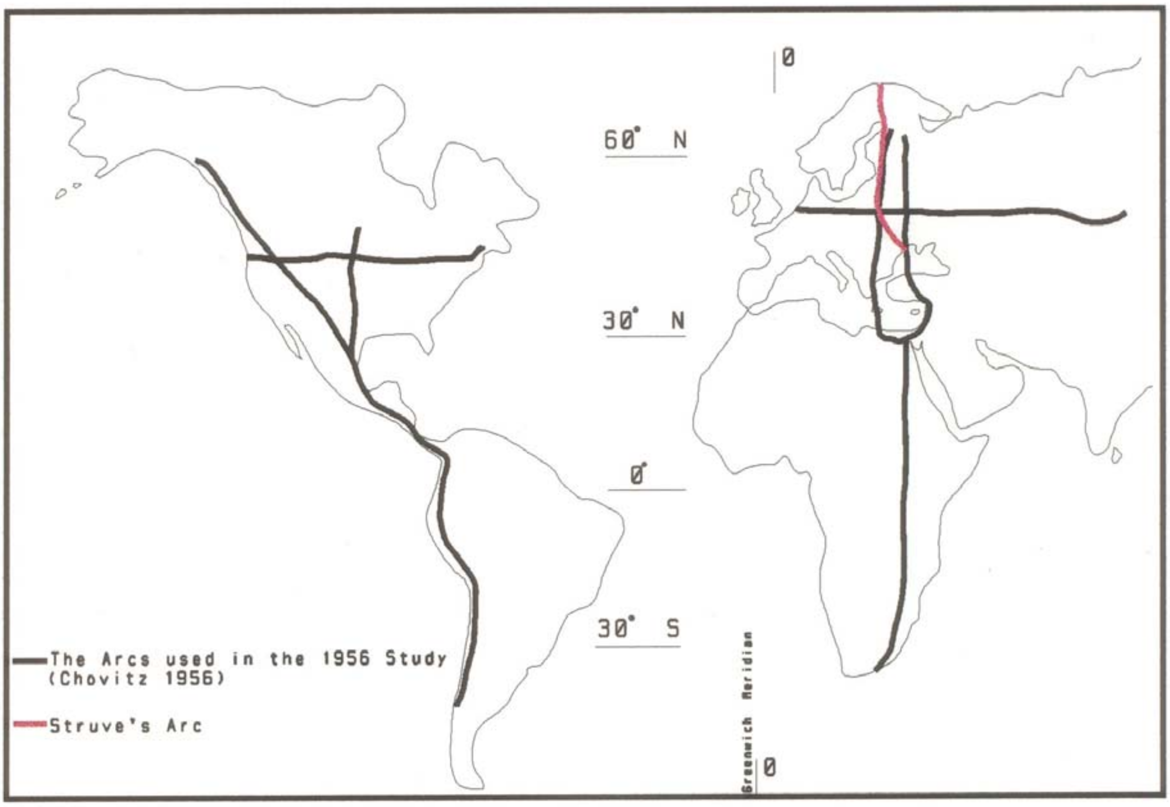

Figure 14.
Struve Arc superimposed in red on those used by Chovitz and Fischer for a new figure of the earth. [Chovitz and Fischer 1956; Army Map Service 1956].

Dick in his paper [Dick 1994] indicates that much of the inspiration for both the European triangulation and the formation of the IAG can be traced to Wilhelm Struve. Unfortunately severe illness prevented Wilhelm Struve from pursuing this and all was passed on to his son Otto. Baeyer however went further in wishing to investigate regional and local anomalies of the figure of the earth and their physical reasons. All however stemmed from the work of Struve on his celebrated meridian arc.

Alfred Petrelius (later Professor at the Technical University of Helsinki) had checked the stations of the Struve arc in Finland during three expeditions in 1886, 1888 and 1889 and had made a catalogue of his findings. At that time only a few points were missing.

More recently new searches were made in 1968 and 1989 on the initiative of Dr Seppo Härmälä and the task to make an inventory of the points in Finland was entrusted to Mr. Aarne Veriö. He has taken the issue seriously and has collected much information. Doing this he has realized that the preservation of the remaining sites was very important to the honour that the Struve arc deserves. [Härmälä 2000; Veriö 1994]

Between 1910 and the 1930s connections were made to the Struve arc in many countries including Norway, Sweden, Finland, Russia, Estonia, Latvia, Lithuania, Poland and Romania.

Then in 1954 the long awaited connection was made between the arc of the meridian from Scandinavia southward and that from South Africa up the 30º meridian. This divided near Cairo into a western chain along the Egyptian coast, stations of which were used in the Shoran connection from Egypt to Crete, and an eastern chain towards Suez that was linked through the Middle East to the Russian arc of the 32nd meridian. [Zakiewicz 1997].

[Chovitz and Fischer 1956] p. 2 states "Within the past two years, [i.e. 1954-56], two important pieces of geodetic work have been completed. The last un-surveyed section of the long anticipated arc of the 30th meridian extending from Scandinavia to South Africa was finished in 1954 by a field party from the [US] Army Map Service; the Hiran* connection from Crete to Egypt, and an alternative connection through the Middle East joined the African portion of the arc to the European portion.”

[Chovitz and Fischer 1956] p. 3 states “. the African arc is also continued in two different paths. In one, it crosses the Mediterranean by means of the Africa-Crete Hiran* connection, and then roughly follows the 24th meridian up to about 65º N . The other path forks eastward through the Levant and continues roughly along the 32nd meridian up to 64º N.”

*(NB. the quotes above each say Hiran, whereas the actual Report [Air Photographic & Charting Service 1954] says Shoran. Hiran is simply a high accuracy version of Shoran).

As shown on figure 14 this gave a measure from near Hammerfest in the north to a point at Buffelsfontein near Port Elizabeth. Although the triangulation does continue on from Buffelsfontein to Cape Point this last section diverges by almost 90º from the meridian. [Zakiewicz 1997]. As a result Chovitz and Fischer, 1956, (see Figure 14) were able to use points on these arcs to determine a new figure of the earth [Chovitz and Fischer 1956]. In 1956 Zhongolovich used the entire Struve arc for a derivation of the earth parameters.

NAMES

In the interval since Struve completed his work many place names have changed. In addition they appear with different spellings in different languages. Some have simply a change of one or two letters, others have completely altered their names. For example Dorpat = Tartu; Leningrad = St Petersburg, Gögland is also found as Högland and Hochland.

The regional names also have changed so that, for example, Bessarabia and Livonia have been divided between Ukraine and Moldova, and Estonia and Latvia respectively.

Note also that many of the national boundaries have also changed position so that some points originally in one country are now in another.

PLACE-NAME ORTHOGRAPHY

The problems with place names as they change over the years is well illustrated by the following extract from [Wennström 2002].

In *Arc du méridien* the spelling of names is with small capitals, e.g. PULLINKI, and the ending VAARA ('mountain') separated e.g PERRA-VAARA. The seven names within Sweden are PERRA-VAARA, PULLINKI, PALJUKKAVAARA, KERROJUPUKKA, LUMI-VAARA, PESSINKI, PAJTAS-VAARA. In the map section spelling is with small letters, e.g. Pullinki

At the time of the Arc survey there was no modern topographical map. Beginning some 20 years later a survey within Sweden covered the area with a 1:200 000 hachured topographical map. At that operation also a more systematic name collection was carried out. When later on also maps at 1:100 000 and 1:50 000 entered the scene still more names were added. In some cases name placement was changed.

PERRA-VAARA now *Perävaara* (map sheet 25N NV). More precisely the point is on a part of the mountain called *Alanen Perävaara,* written *Ala Perävaara* in an earlier version of the map.

PULLINKI unchanged, *Pullinki* (map sheet 27M SO). The name appears as *Pullingi* in the old District Map or Häradskarta*,* 1878. Also PALJUKKAVAARA is unchanged, *Paljukkavaara* (28M SO).

As for KERROJUPUKKA the former part is probably *Käry-* (thus *Käryjupukka)* as the mountain is close to *Kärykoski* rapids in the Tornio river and is surrounded by *Käryjänkkä* and *Käryjänkänlehto* (28M NV). The name Kerrojupukka was not used in later 19th century surveys. It is shortened to *Jupukka.*

LUMI-VAARA, now *Lumivaara* (29M SV). It should be noted that the Struve point is on a southeastern minor summit called *Palolaki* about 950 m from the main Lumivaara summit. At Palolaki there is a parish boundary kink between Junosuando and Pajala parishes. The main summit has been entered into some later survey protocols as *Lumivaara (Huornanen)* but Huornanen is the name on another mountain in this area.

PESSINKI, unchanged *Pessinki* (30L SO). The name refers to a vast area and is used also for the Pessinki nature preservation area, covering 972 sq km. There are very few minor names and the Struve place is marked by a spot height only (510,2 m).

PAJTAS-VAARA, now *Paittasvaara* (30L NO). The *Paittasvaara* mountain and the *Paitta järvi* lake with a small settlement with same name, are the "big" names in the area. The Struve point is however not located on Paittasvaara (434 m) west of the lake. Instead it is within an easterly mountain complex called *Pingisvaara* and on its highest and steepest summit, *Tynnyrilaki* (445 m). To avoid mistakes the Struve point should be renamed *Tynnyrilaki* or at least this name be added.

The Swedish side of the Tornio valley *(Tornedalen)* is a multilingual area, where Swedish, Sami and a variety of Finnish *(tornedalsfinska)* are spoken. During the 1990s the name 'Meänkieli' i.e. 'our language' was widely accepted for this last mentioned language variety, and it was given the status of a minority language within this part of Sweden. [Westergren and Åhl 1997].

A WORLD HERITAGE MONUMENT

Following from his researches Veriö prepared a paper to present at a scientific conference in Tartu in 1993 [Veriö 1994] but he was unable personally to be there. However the paper was presented on his behalf together with his idea for seeking a UNESCO declaration to preserve the remaining points as a World Heritage site.

The Scientific Conference in Tartu took forward the idea and on August 28, 1993 agreed the following

Resolution No. 1.

"Considering the scientific, historical and practical importance of the measurement of the arc of meridian through Tartu, made by F.G.W. Struve,

Urge the governments of those countries that still possess relics of that enterprise to take all possible steps to preserve those relics, including an approach to UNESCO to declare them to be World Heritage sites."

A corresponding resolution 1/2 1994 was then made at the FIG Congress at Melbourne in 1994.

"Considering the great historical value of the measurement of the arc of the meridian, and that an inventory exists of land monuments marking the arc of the meridian, called Struve, which extends over 9* countries and 25º of latitude from the Black Sea to Hammerfest situated on the north coast of Norway, Commission 1 recommends that FIG should present a request to the United Nations that the remains of this arc of meridian be added to the World Heritage List of Historical Monuments". (*Note that one country, possibly Russia, was overlooked.)

Further on a resolution No B10 by Commission 41 of the International Astronomical Union (IAU) was made at its General Assembly in The Hague in 1994.

"Considering the scientific, historical and practical importance of the measurement of the arc of meridian made by F G W Struve

Urges the Executive Committee of the IAU to approach the governments of the following countries: Norway, Sweden, Finland, Estonia, Latvia, Lithuania, Ukraine, Belarus, Poland and Moldova, which still possess relics of that enterprise, with a view to taking all possible steps to preserve those relics, including an approach to UNESCO to declare them to be world-heritage sites." (It will be noticed that the drafters of this resolution mistakenly included Poland and omitted Russia.)

In an e-mail of March 1996 The International Association for Geodesy (AIG) also expressed its support.

A similar conference to that of 1993 was held in Tallinn and Tartu from 25 to 28 September 2002 under the title "Struve Arc 150". About 50 delegates from eight countries of the Struve Arc attended - namely Norway, Sweden, Finland, Russia, Estonia, Latvia, Lithuania and Belarus. Also participants from UK and Belgium attended. Essentially it was commemorating the 150th anniversary of the completion of the Struve Geodetic Arc, but was an ideal opportunity to discuss the arc in detail and to progress the efforts of the National Land Boards of the concerned countries and International Institution for the History of Surveying & Measurement to have selected points in each country recognised on the World Heritage List. In this Conference the coordinating role of the Struve Arc World Heritage project was given to the National Land Survey of Finland, chaired by Jarmo Ratia and Pekka Tätilä as Project Manager. The nomination having the sole governmental character has to have a strong participation from respective National Land Boards of countries.

Four resolutions were passed, of which the following two were the most important:

Resolution No. 1.

"Following Resolution No. 1 from the International Scientific Conference held in Tartu in August 1993 and resolution No. 1 of FIG, Melbourne Congress in 1994 the participants in the International Scientific Conference held in Tallinn and Tartu, Estonia, on September 26-28 2002 to honour the scientific achievements of

F.G.W.Struve,

considering the scientific, historical and practical importance of the measurement of the arc of meridian through Tartu which stretches from near North Cape in Norway, through Sweden, Finland, Russia, Estonia, Latvia, Lithuania, Belarus, Ukraine and Moldova to the Danube Delta made under the guidance of F.G.W.Struve,

urge the authorities in the 10 countries through which the Struve arc passes, to complete the preservation of the arc of meridian and the documentation in their countries as soon as possible, so that in their turn the national representatives to UNESCO may be urged to put them on their national provisional list of World Heritage Monuments."

Resolution No. 4

"The participants in the International Scientific Conference held in Tallinn and Tartu, Estonia, on September 26-28, 2002 to honour the scientific achievements of F.G.W.Struve,

▪ considering the historical importance of the measurement of meridian arcs

▪ encourage the International Institution for the History of Surveying & Measurement to continue its investigation into the connection between the Struve Meridian Arc and the Arc of the 30th Meridian in East Africa,

▪ urge the authorities of those countries concerned to assist in all ways they can to preserve selected points in their countries so that it is possible to achieve the aim of a World Heritage Monument stretching from near the North Cape of Norway at latitude 70º 40' 11" N to latitude 33º 59' 32" S in South Africa, making it the longest monument in the world."

The desired World Heritage declaration requires that the included Struve stations are already protected in those countries where they are situated. This task was not easy because the legislation deviates from one country to another.

There is still one other issue to be addressed. The tome in French by Struve where the Arc was documented [Struve 1860], is valuable and interesting and belongs to the history of surveying. Unfortunately the book is now a rarity, and seldom found in libraries. It is uncertain whether it is even available in all of the ten countries involved. It is true, some chapters from it have been reprinted in Russian in 1957 in Moscow but even that must now be out of print there. [Härmälä 2000]

It would be a cultural achievement to reprint the tome. In French it could be a facsimile product, but still better if it could be in English to reach more readers. This aspect of the Struve arc will, it is hoped, be part of the project to index the Struve archive that remains in St Petersburg and Moscow.

PREPARATIONS FOR NOMINATION

But how then does all this fit into the concept of a World Heritage monument? Such monuments approved to date have all been very large structures or features for which the area is often measured in many hectares. With the arc, the area covered by the chain of triangulation is large but the actual survey stations defining it are essentially point positions only and even with any cairn that covers some of them the area taken up is but a few square metres per point. That does not appear to present a problem to the authorities who rather see the unusual concept as a challenge.

Today the Struve arc passes through ten countries - Norway, Sweden, Finland, Russia, Estonia, Latvia, Lithuania, Belarus, Moldova and Ukraine. Each of these countries contains a good number of the Struve stations except Russia that has only one main point – on the island of Hogland in the Gulf of Finland.

The arc in total consists of 265 main points plus some ancillary ones in base extension networks. Of these a few are already permanently monumented such as those at Fuglenaes in North Norway, and Staro-Nekrassowka in the Ukraine. Both have inscribed obelisks. For calculation purposes Struve numbered 258 triangles.

The aim of the submission was to select some one to six points in each of the ten countries that are recoverable as definite Struve positions and to have them marked in some commemorative manner. Those selected would be in positions of reasonable access to the public and be spread throughout the country. (Some in North Norway for example require a helicopter to achieve access or alternatively several hours trek).

The structure (if any) at the selected points would possibly vary from country to country but each would bear a similar plaque giving the briefest of information about the arc and the particular point.

Each of the countries involved was required to first of all identify a selection of points and then to indicate how they would see them being permanently marked and maintained in good order and access. The authority for this was needed to come from the national government department concerned. Considering the age of the points, the difficult access to the vicinity of many of them and the difficulty of recovering the ground mark, the task of compiling a summary for submission to UNESCO took considerable effort to complete.

The compilation of the official document of "Nomination of the Struve Geodetic Arc to the inscription on the World Heritage List" has been coordinated by Pekka Tätilä from the National Land Survey of Finland. The arc passes through that country from the south to the north - having more than 30 % of its point within the territory of Finland - and much of the material necessary is also available there.

In the future it would be hoped to mount a re-measuring exercise by GPS at the selected points and to use that to investigate the accuracy of the original work. That could then lead to further investigative work relating to the original observations and form an historical data bank for any future scientific work.

THE FUTURE

If the project detailed here should come to a successful conclusion then it would not be impossible to extend the idea south into Africa and down the 30th meridian to South Africa. As was indicated by [Chovitz and Fischer 1956] for purposes of determining the figure of the earth the arc of the 30th meridian was linked across the Mediterranean to European arcs. Thus it could be an extension of the Struve meridian arc project to continue through the African arc and so preserve a series of points from the North Cape to Port Elizabeth or even along to Cape Point although this last section is not strictly part of the arc of the 30th meridian.

ACKNOWLEDGEMENTS

A project such as that for the Struve Geodetic Arc requires co-operation from many people. Thanks are due to the National Survey Organisations and contacts in all the countries concerned as listed in another part of this dossier.

This "Background" section has been compiled and edited by Jim Smith and Pekka Tätilä.

In particular it has drawn considerably from the papers by Härmälä [2000], Wennström [2002] and Harsson et al. [1994] and extensive correspondence with Vitali Kaptjug.

Figures 1,2,6 and 7 are taken from [Smith 1988], Figure 5 is from [Struve 1860], Figures 8-11 are from [Smith 1986].

It is appropriate here to acknowledge a financial grant from the RICS Education Trust to assist with the indexing of the Struve archive.

Sincere thanks are expressed to the personnel of the National Survey Organisations, which from the very beginning up to the final stage have been involved into the project and which have been in the charge of the preparations and collected the data, selected the points and documented sites for the Nomination:

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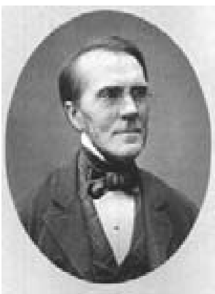
Dramatis personae

A few words about the principal individuals involved are appropriate here.

Hansteen

Christopher Hansteen was born 26 September 1784 in Christiana now Oslo and died in the same city 15 April 1873. He studied law at Copenhagen and later became Professor at Christiana, Director of the Observatory and Chief of Geographic work in Norway. By 1817 as a President of the Geodetic Institute he played a leading role in the survey of Norway. He was particularly interested in geomagnetism and magnetic charting. For his part he was in charge of 1º 46′ of the arc between Atjik and Fuglenaes on the isle of Kval-Ö, or from 68º 54′ to 70º 40′ with one baseline and 12 principal triangles.



Lindhagen

Daniel Georg Lindhagen was born on 27 July 1819 in Askeby near Linköping, Sweden and died 5 May 1906. He was a Swedish astronomer who worked in Pulkovo before returning to Sweden to work for a few years after his marriage. He spent two summers on survey work in Lapland. At that time Struve was over 50 years old and headed the Observatory in Pulkovo so he delegated the astronomical work to Lindhagen whose detailed reports for 1850 and 1851 are presented as appendices in the *Arc du Meridien* [Struve 1860]. Later he became permanent secretary to the Royal Academy of Sciences in Stockholm. He married Wilhelm Struve's daughter Olga. [Batten 1988].

Maupertuis

Pierre-Louis Moreau de Maupertuis was born 28th September 1698 in St Malo and died on 27th July 1759 in Basel. On 8 October 1745 he married Eleonore Catherine von Borck. He was said to have been a spoilt child and this resulted in a certain intransigence and unwillingness to be criticised that later led him into difficulties. His early education was private. His father was ennobled by Louis XIV as Ren, Moreau Sier de Maupertuys. After studying in Paris he was in the French army until 1723 when he became involved in the French Academy of Sciences.

By 1728 he strongly believed in Newton's idea on the shape of the earth and began to work on his own theories and even published a treatise on the figure of the earth, which signalled the beginning of the establishment of the Newtonian hypothesis in France. In 1736 he led an expedition to Lapland to make a measure of a meridian arc and he was later involved in further arc measurements in France. In 1745 he accepted an invitation from Frederick the Great to go to the Academy of Sciences in Berlin where he became its President.

Selander

Nils Haqvin Selander was born on 20 March 1804 in Vibyggerå, Ångermanland, Sweden and died 18 June 1870 in Stockholm. An astronomer and geodesist who became Director of the Stockholm Observatory. In 1833 he was elected a member of the Swedish Academy of Sciences and began assisting at Stockholm Observatory. From 1850 to 1869 he was Professor of Geodesy at the Topographic Corps which was responsible for topographical mapping of Sweden and of its geodetic systems.

Struve visited Sweden in 1844 and contacted the Swedish Academy of Sciences. The initial idea was to follow the Svanberg Arc and incorporate it. However a Report by Selander and Wrede indicated that the best solution was to complete the Struve arc over the longest possible distance. Selander and Wrede had planned the Arc as a separate Swedish work from Tornea to Kautokeino where there would be a connection to Norway. Although initially intending to do their own computations the work was finally made in Pulkovo in 1855. He was in charge of the 3º 13′ of the arc between Tornea and Bäljatz-vaara or between 65º 50′ to 69º 03′ and with one baseline and 21 main triangles.

He was one of the four persons who signed the report *Arc du Méridien* “sou la direction de”, de Tenner, Hansteen, Selander and Struve. [Harsson 2002].

Struve

Friedrich Georg Wilhelm Struve was born in Altona, Holstein 15 April 1793 and died 23 November 1864 in Pulkovo, Russia. When in Russia he came to be known as Vassily Jakovlevich however he always used his original initials F.G.W. or the name Wilhelm, later with "von” because of his noble status. In the list of his works in his major volume [Struve 1860] he used the initial W. rather that F.G.W. He married twice with a total of 18 children. He graduated in philology from Dorpat and started work at the University observatory. By the age of 20 he became Professor of Mathematics and Astronomy at Dorpat. His involvement in the survey of Livonia was the start of almost 40 years of work on the meridian arc. As a result of which, in 1857 he proposed the measurement of an arc along 45º latitude covering 53º from the west coast of France Brest to the mouth of the Volga Astrakan. He was a founder of Pulkovo astronomical observatory, then the best in the world, and of the Russian Geographical Society and belonged to some 40 scientific academies, learned societies and the like. He was in charge of 9º 38′ of the arc between the Duna and Kaakama-vaara or from 56º 30′ to 66º 08′ and contained 3 baselines and 100 principal triangles.

Svanberg

Jöns Svanberg was born 6 July 1771 in Neder-Kalix, Norrbotten, Sweden, and died 15 January 1851 in Uppsala. By 1787 he was studying at Uppsala University where he was to later become Professor of Mathematics.

During the period 1799-1801 he led a team that re-observed the work of Maupertuis 60 years earlier at the north end of the Gulf of Bothnia. In doing so he extended the original scheme. He had a love of decimals which is evident in the exaggerated accuracy he quoted in his observations and complicated calculations.

Tenner

Carl F. de Tenner, or in the Russian manner, Karl Ivanovitsch de Tenner was born 22 June 1783 near Narva and died 28 December 1859 in Warschau. He spent much of his working life on the arc measurement.

He became a professional surveyor by, presumably self-education, as did Struve and Bessel. He participated in many war campaigns against Napoleon's troops, where his courage was rewarded with a golden sword and other Orders. In 1816 he was appointed head of the vast Russian triangulation work in western provinces of the Empire where he spent much of his working life. It was he who started measurement of a meridian arc in 1817 south of Livonia just on his own initiative, without any funds. He was in charge for a portion of 11º 10' between the Danube and the Duna or from 45º 20' to 56º 0' N, and which contained 5 baselines and 125 principal triangles.

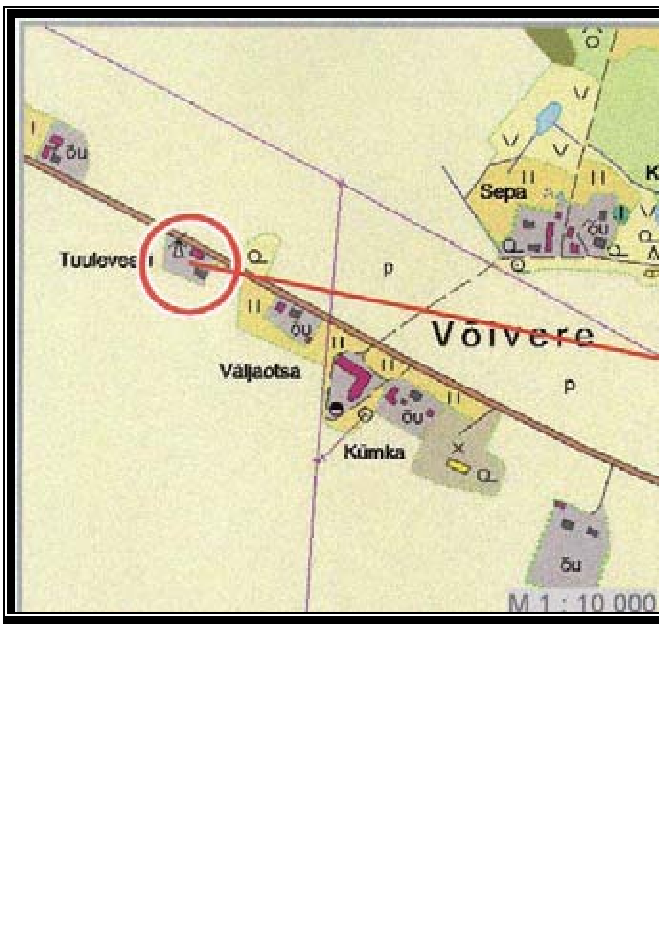
He became Struve's friend, and had contact with F. Bessel and other prominent scientists. He was an Honorary Member of the Russian Academy of Sciences.

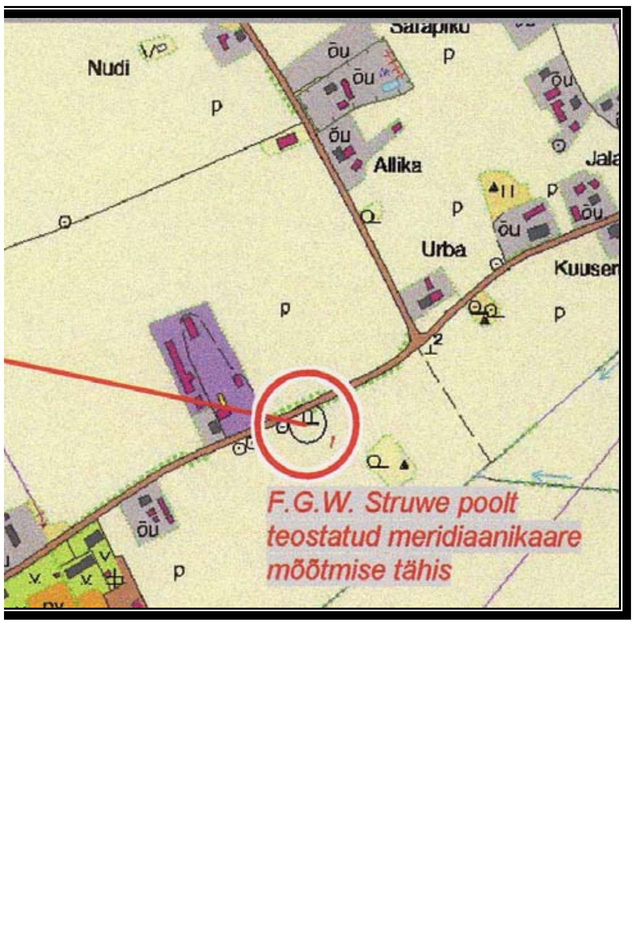
Appendix II

MAPS

of

THE STRUVE GEODETIC ARC





MAPS

APPENDIX II

to

Nomination of the

STRUVE GEODETIC ARC

for inscription on the

WORLD HERITAGE LIST

January 2004

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In most cases the size or dimensions of these zones has been given only in the capture of the map and then the symbol round the site just indicates the location of the site.

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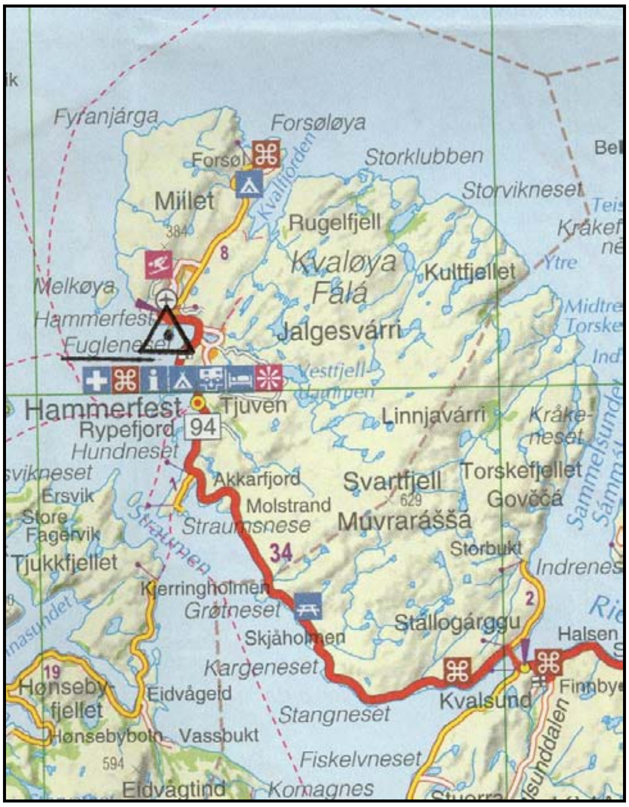

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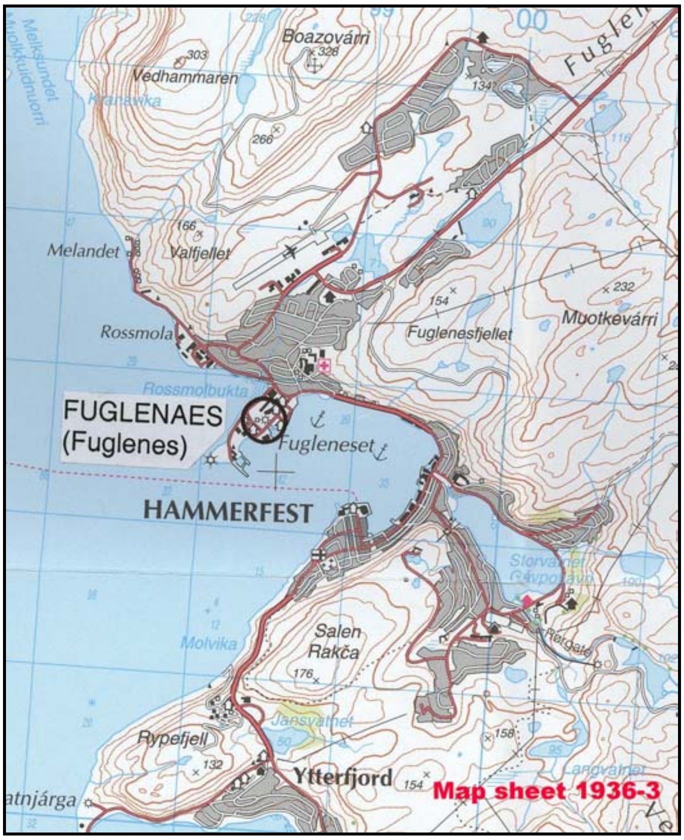

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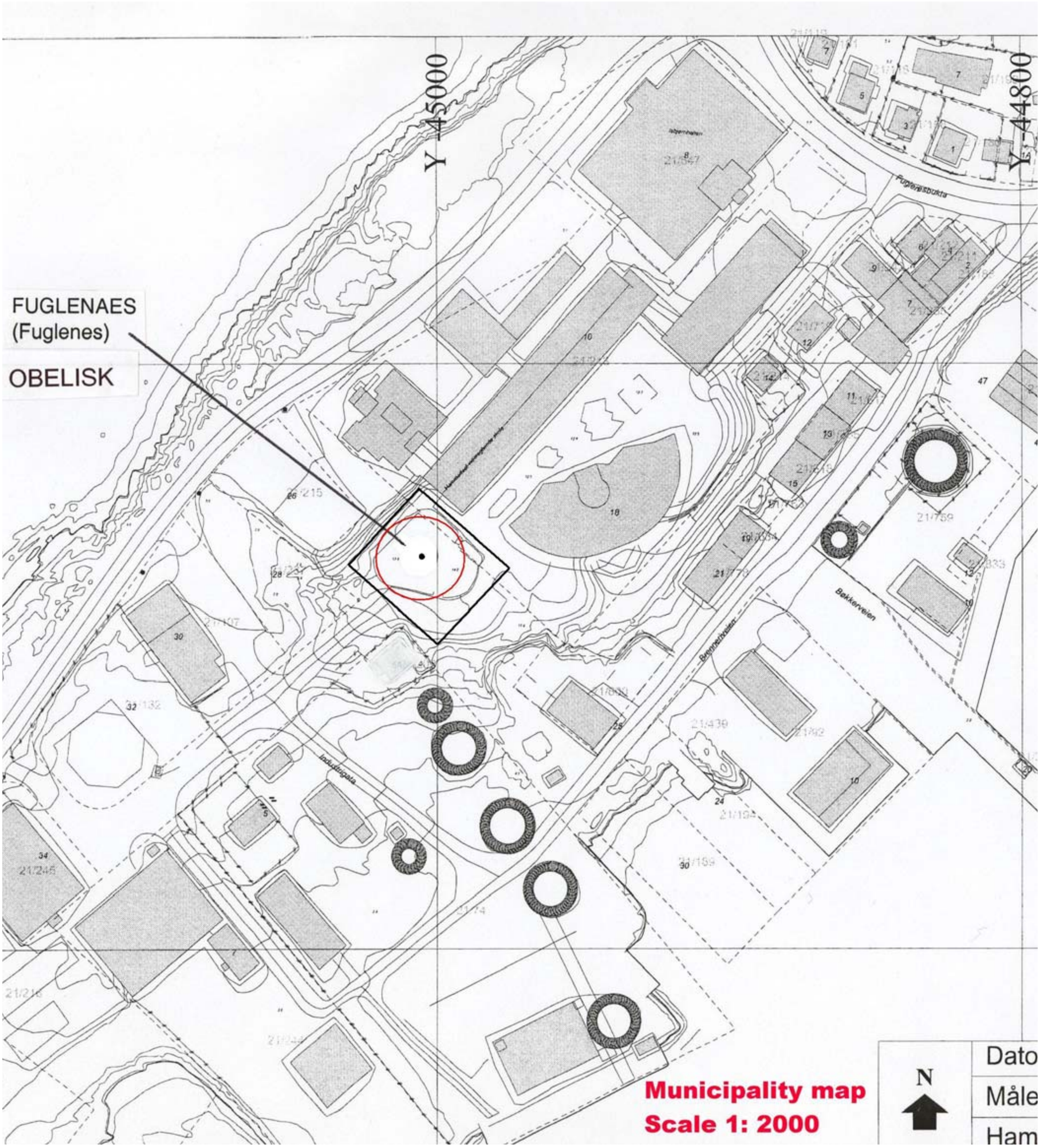

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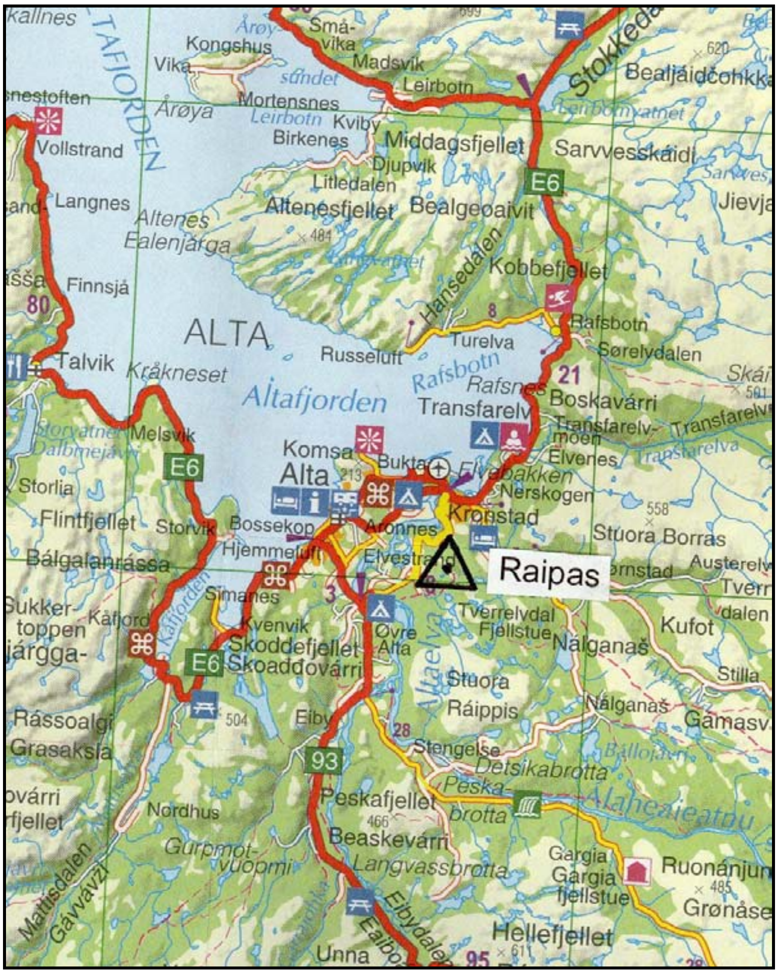

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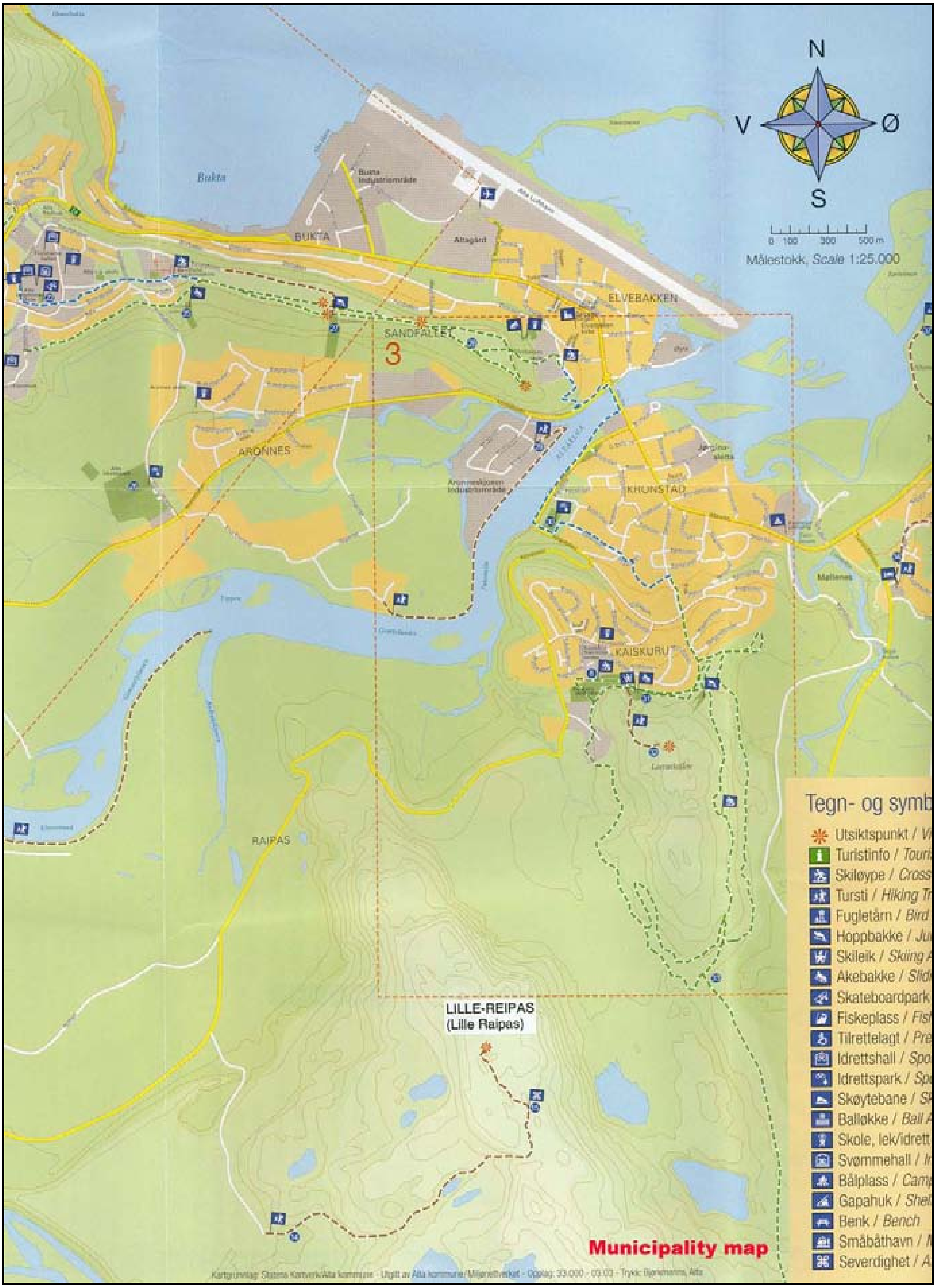

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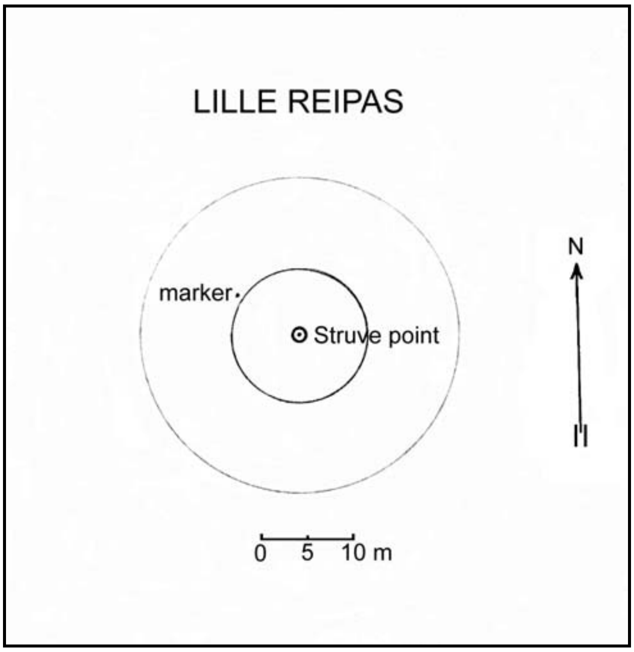

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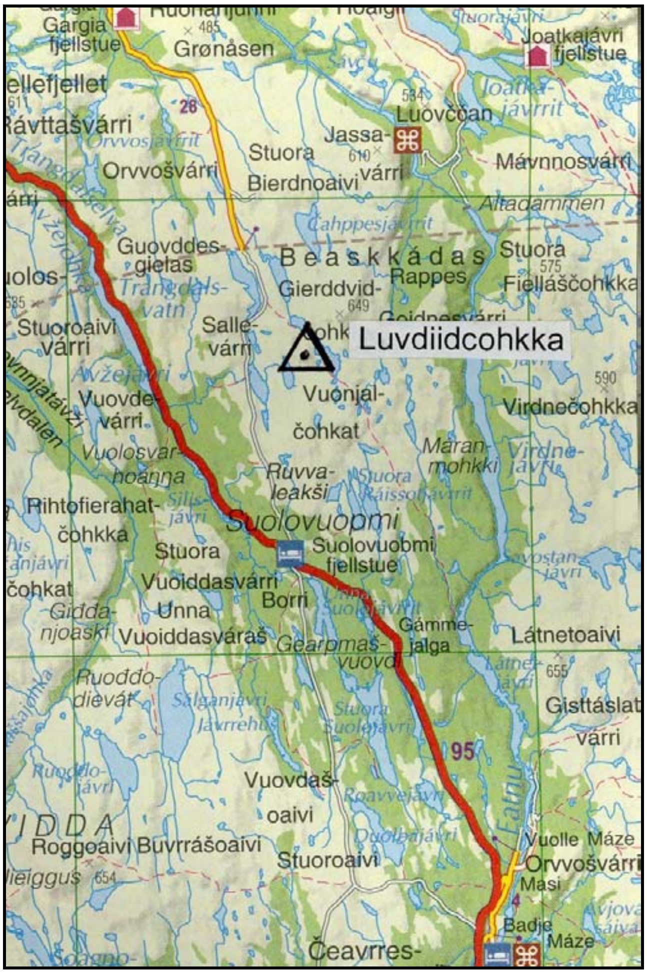

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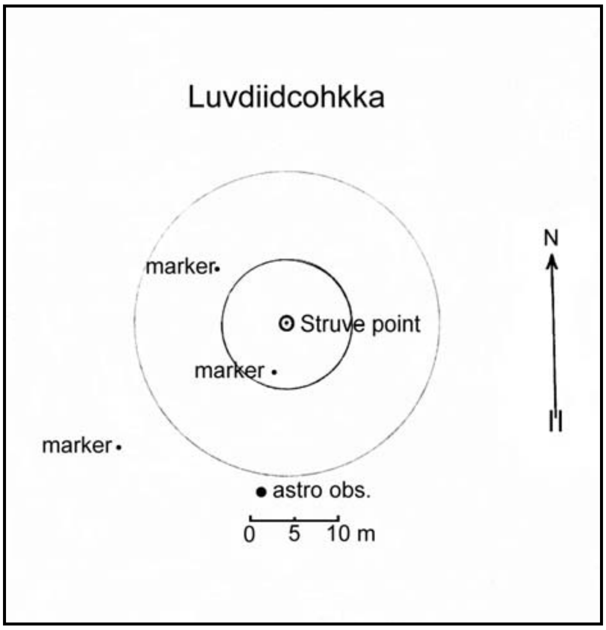

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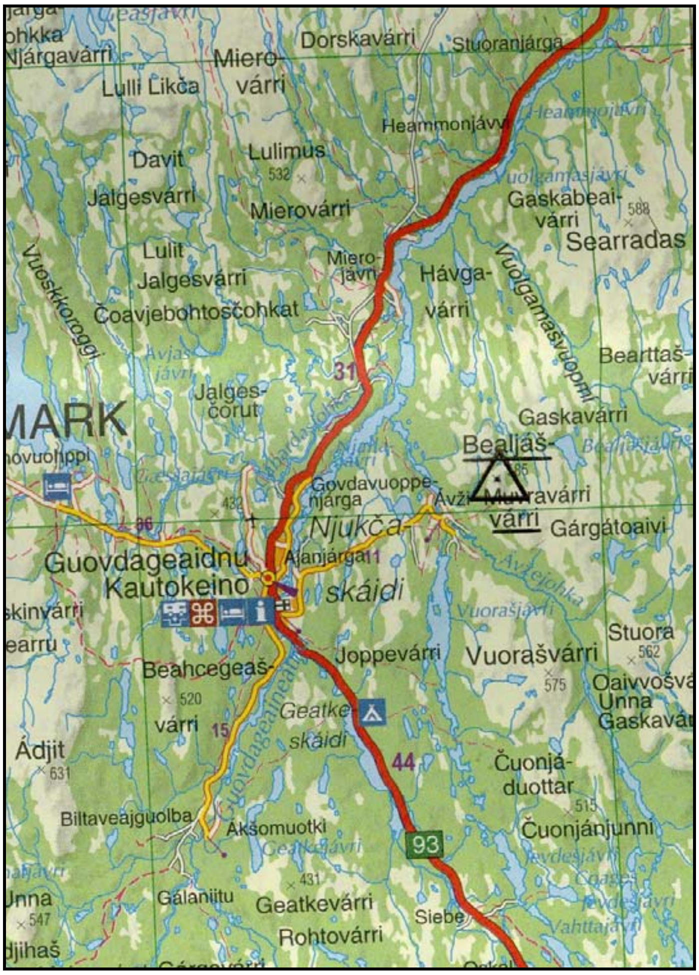

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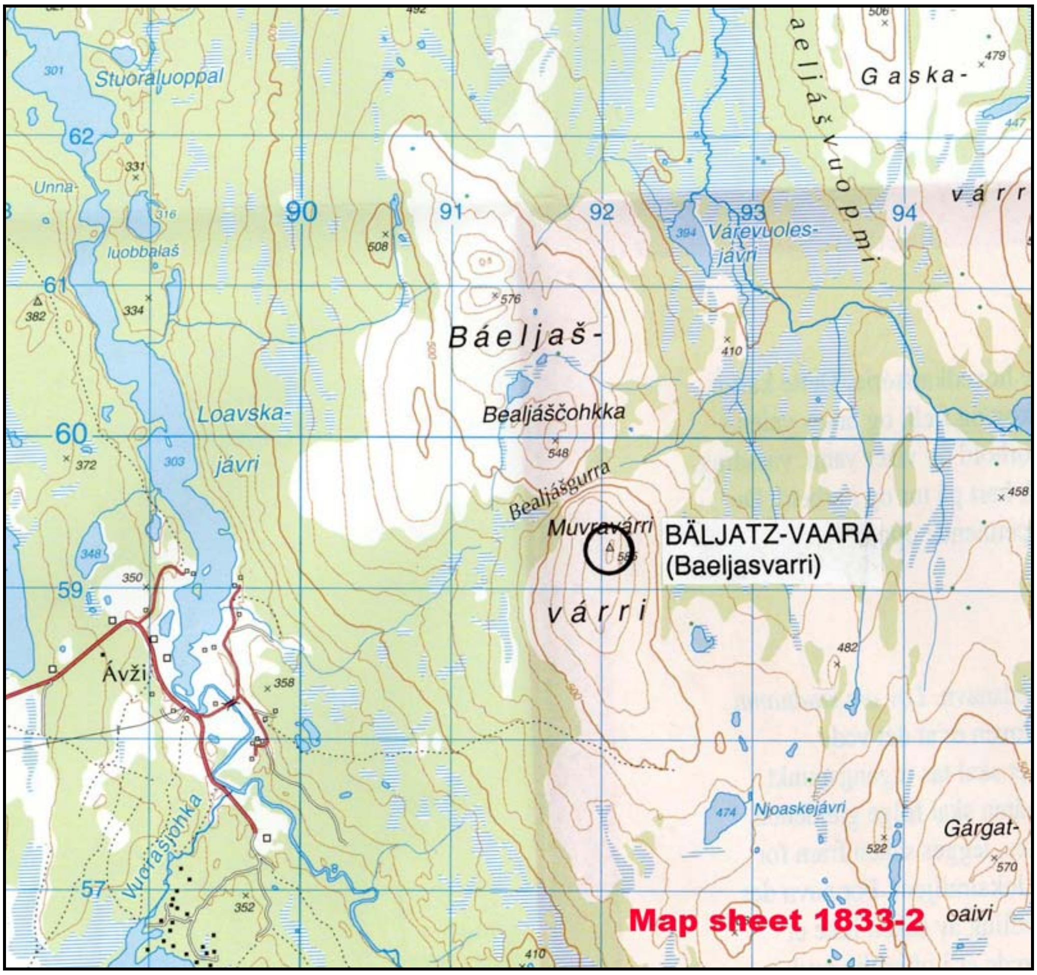

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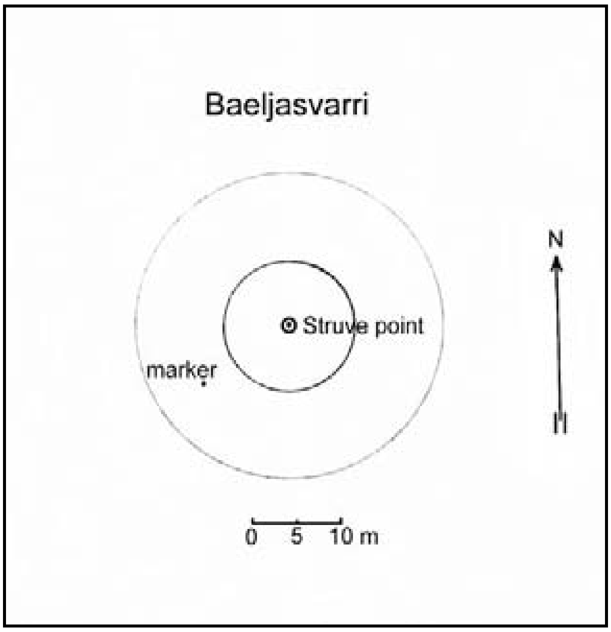
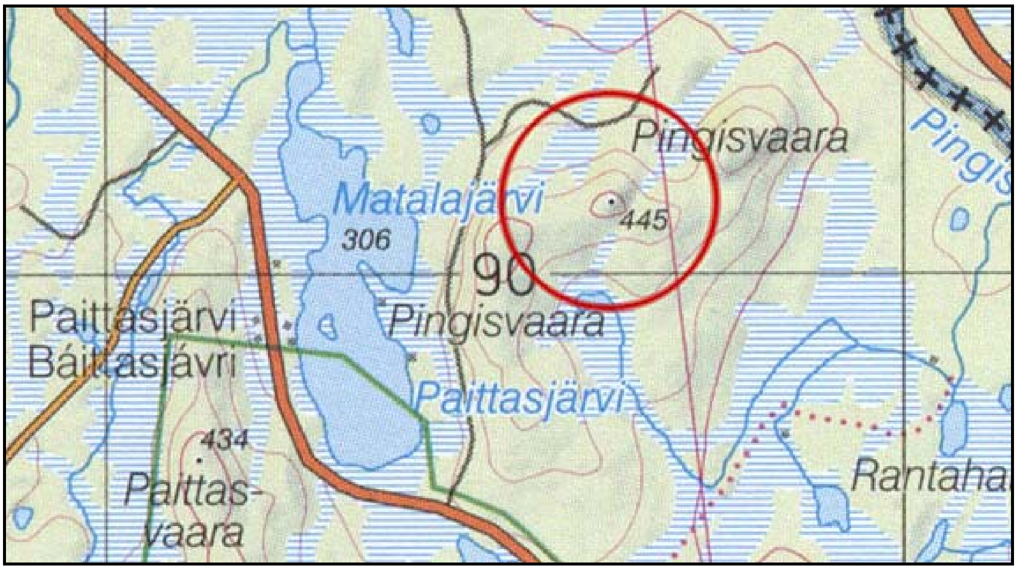
BÄLJATZ-VAARA (4).
Basic Map, 1:50.000. Map sheet 1833-2, Norwegian Mapping Authority, 2001.



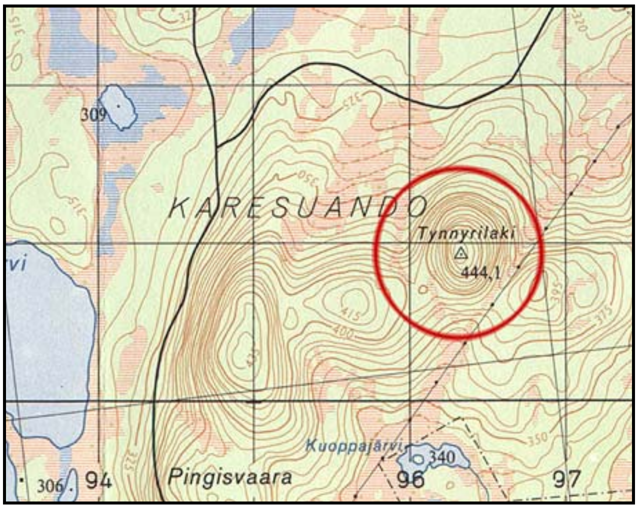
Map 13.

BÄLJATZ-VAARA (4).
Plan with the core zone (radius 5,6 m) and buffer zone (radius 17,8 m).



Map 14.

PAJTAS-VAARA (5).
General Map. 1:100.000, Map sheet 1 Kiruna, 1998. (Original scale 1:250.000).



Map 15.

PAJTAS-VAARA (5).
Topographical Map. 1:50.000, Map sheet Lannavaara, 30L NO, 1989.

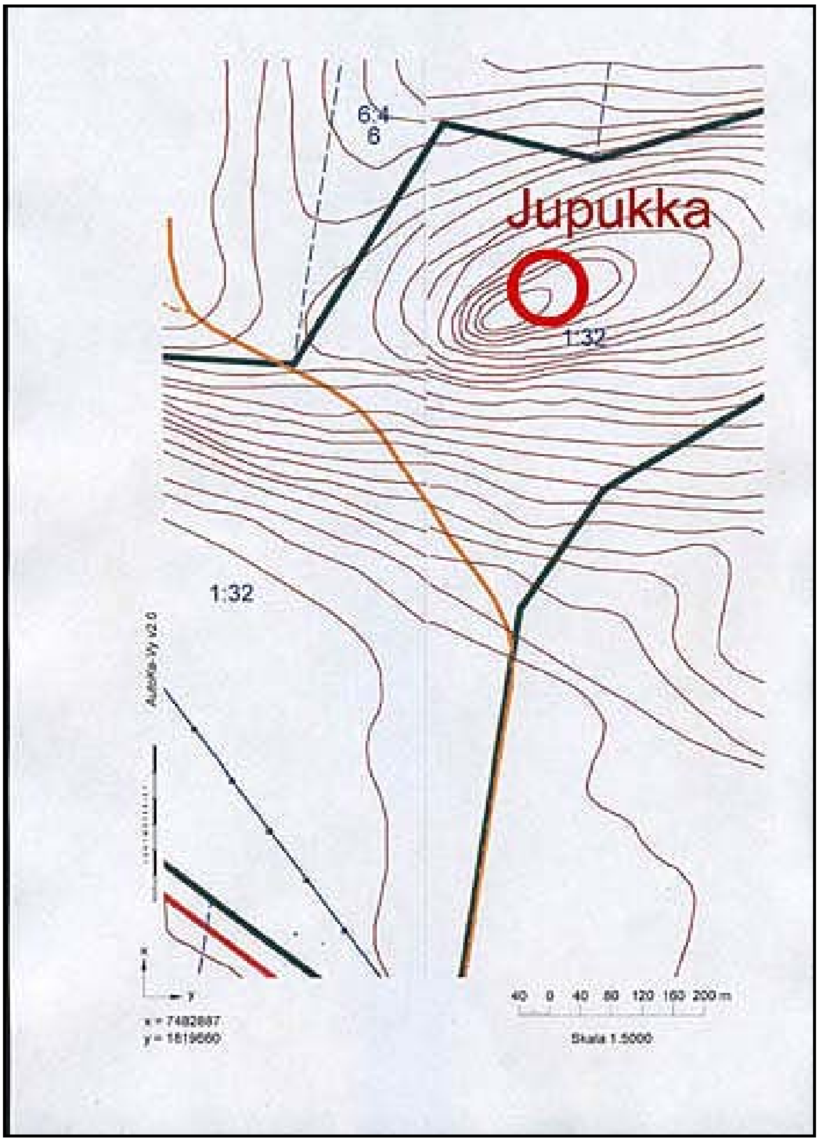
In the field the core zone is a circle with diameter of 11,4 m and
the buffer zone a circle with diameter of 35,6 m
(not marked on the map).
The e grid size on the map is 1*1 sq. km in the field.

Map 16.

KERROJUPUKKA (6).
General Map. 1:100.000, Map sheet 1 Kiruna, 1998. (Original scale 1:250.000).

Map 17.

KERROJUPUKKA (6).
Topographical Map. 1:50.000, Map sheet Pajala, 28M NV, 1989.



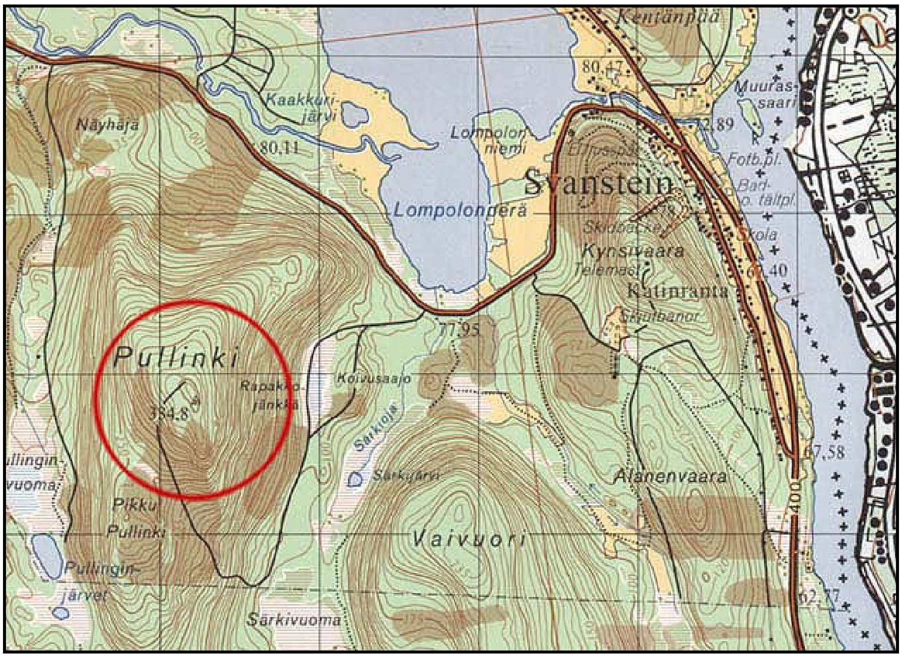
Map 18.

KERROJUPUKKA (6).
Land Register Map. 1:10.000, Extract from database (original in scale 1:5000).

The core zone in map scale is a circle with diameter of 1,13 mm and
the buffer zone a circle with diameter of 3,57 mm
(not marked on the map).

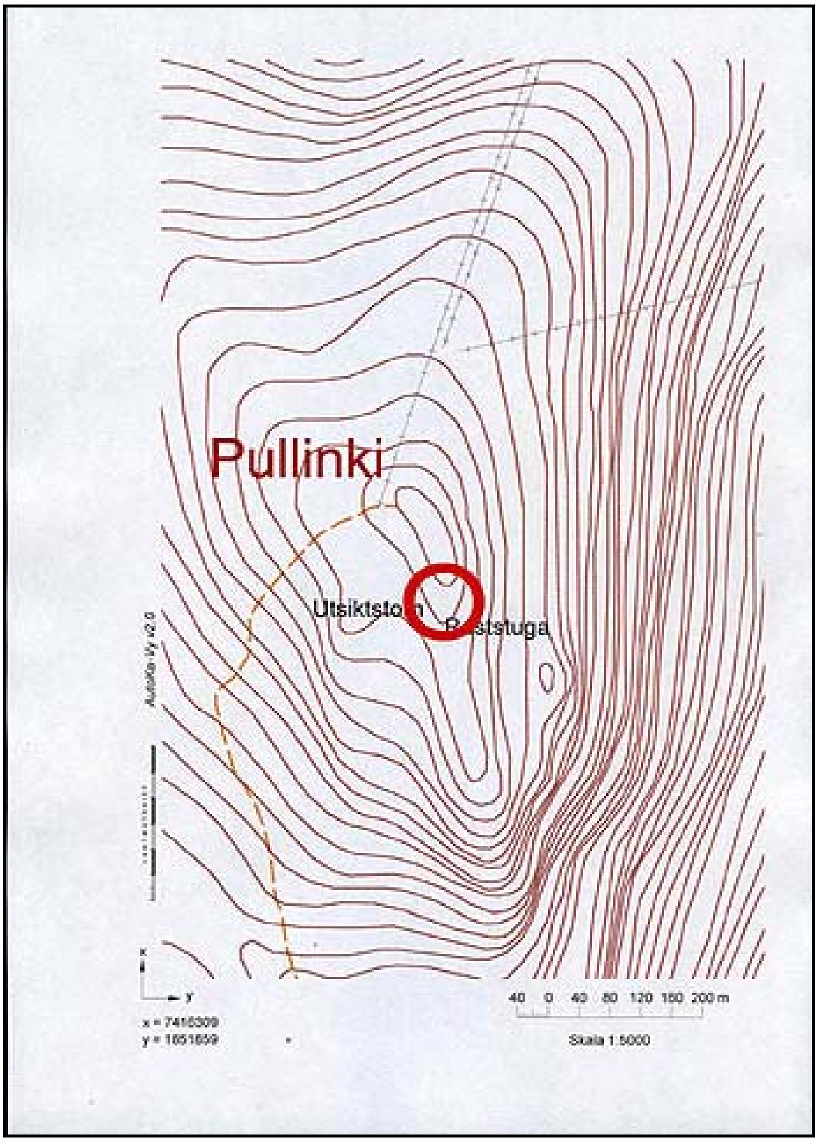
Map19.

PULLINKI (7).
General Map. 1:100.000, Map sheet 3 Luleå, 1998. (Original scale 1:250.000).



Map 20.

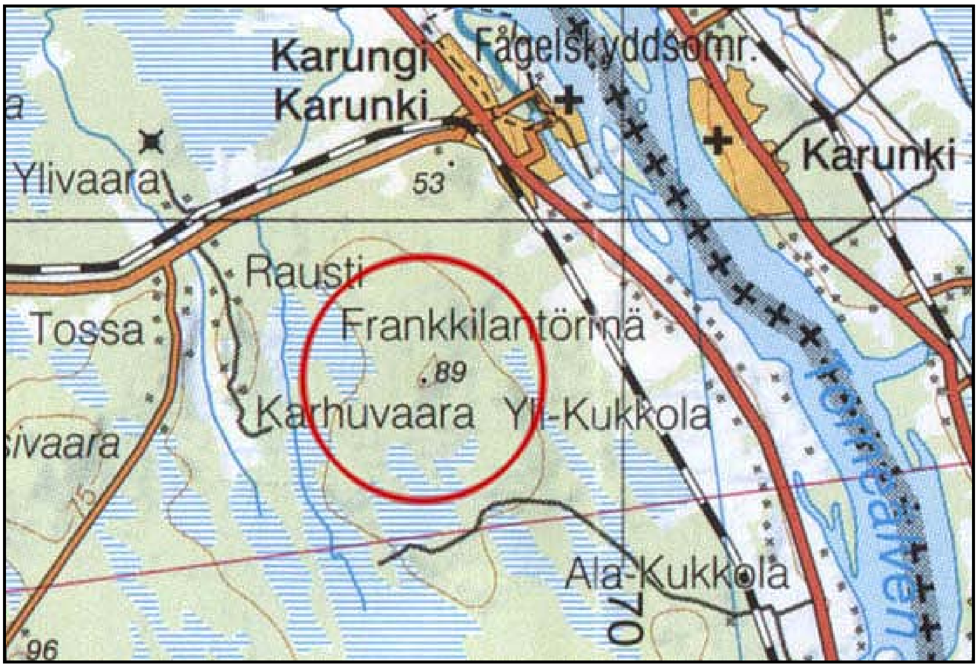
PULLINKI (7).
Topographical Map. 1:50.000, Map sheet Korpilombolo 27M SO, 1999.



Map 21.

PULLINKI (7).
Land Register Map. 1:10.000, Extract from database (original in scle 1:5.000).

The core zone in map scale is a circle with diameter of 1,13 mm and
the buffer zone a circle with diameter of 3,57 mm
(not marked on the map).



Map 22.

PERRA-VAARA (8).
General Map. 1:100.000, Map sheet 3 Luleå, 2000. (Original scale 1:250.000).

250.000

Map 23.

PERRA-VAARA (8).
Topographical Map. 1:50.000, Map sheet Haparanda 25N NV, 2000.

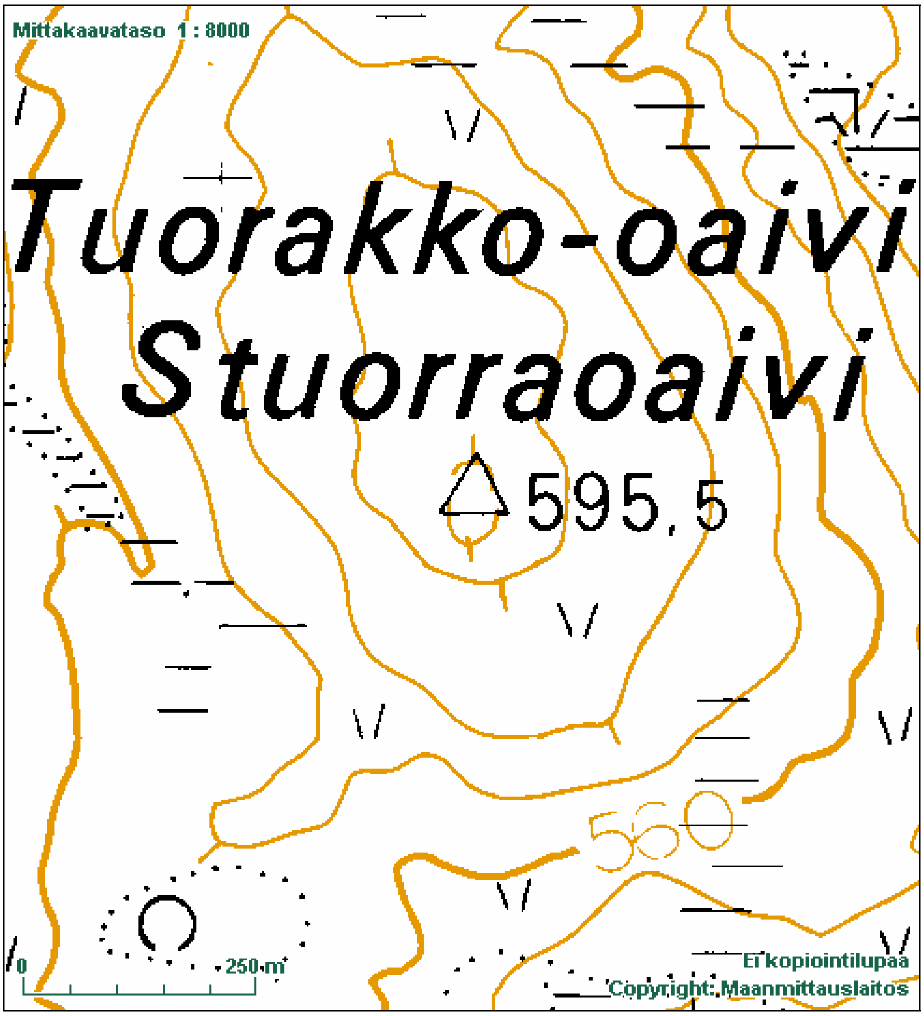
Map 24.

PERRA-VAARA (8).
Land Register Map. 1:10.000, Extract from database (original scale 1:5.000).

The core zone in map scale is a circle with diameter of 1,13 mm and
the buffer zone a circle with diameter of 3,57 mm
(not marked on the map).

Map 25.

STUOR-OIVI (9).
Topographical Map 1:80.000, Extract from database, 2003.



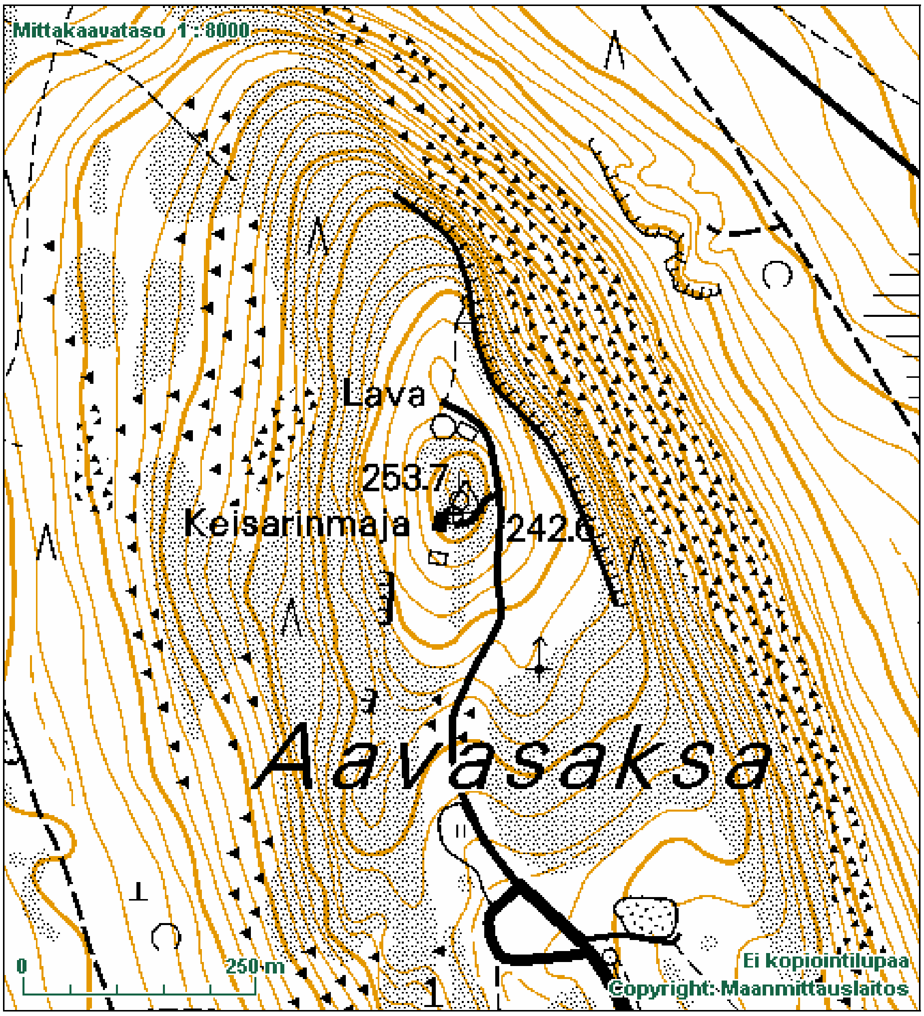
Map 26.

STUOR-OIVI (9).
Topographical Map 1:8.000, Extract from database, 2003.

The site is marked on the map with a triangle.
The core zone in map scale is a circle with diameter of 2,5 mm (in the field 20 m) and the buffer zone a circle with diameter of 6,25 mm (in the field 50 m).
(Zones are not marked on the map).

Map 27.

AVASAKSA (10).
Topographical Map 1:80.000, Extract from database, 2003.



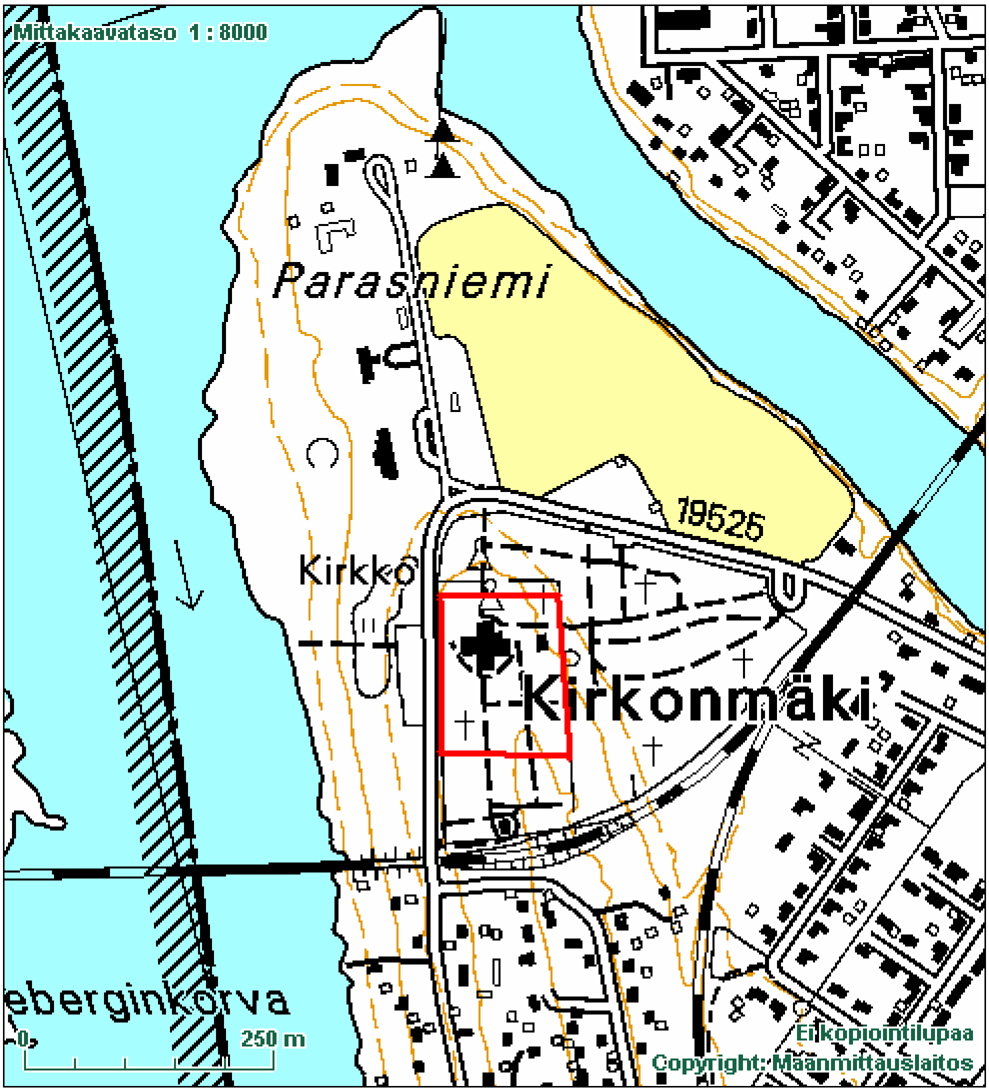
Map 28.

AVASAKSA (10).
Topographical Map 1:8.000, Extract from database, 2003.

The site is marked on the middle of the map with a triangle.
The core zone in map scale is a circle with diameter of 1,25 mm (in the field 10 m) and the buffer zone a circle with diameter of 12,5 mm (in the field 100 m).
(Zones are not marked on the map).

Map 29.

TORNEA (11).
Topographical Map 1:80.000, Extract from database, 2003.



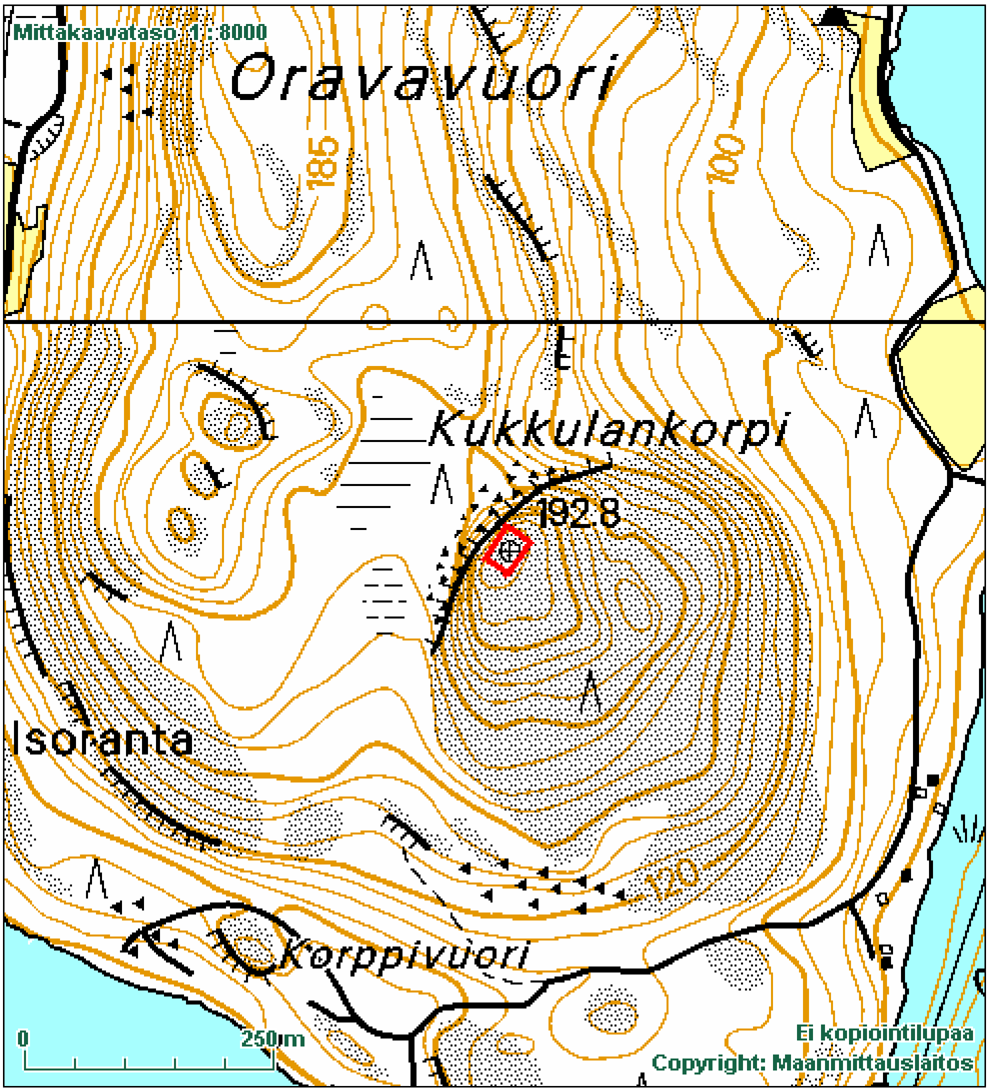
Map 30.

TORNEA (11).
Topographical Map 1:8.000, Extract from database, 2003.

The site is marked with the cross symbol of the church.
The core zone is as large as the foundation of the church (the cross on the map) and the buffer zone is marked with a parallelogram.

Map 31.

PUOLAKKA (12).
Topographical Map 1:80.000, Extract from database, 2003.



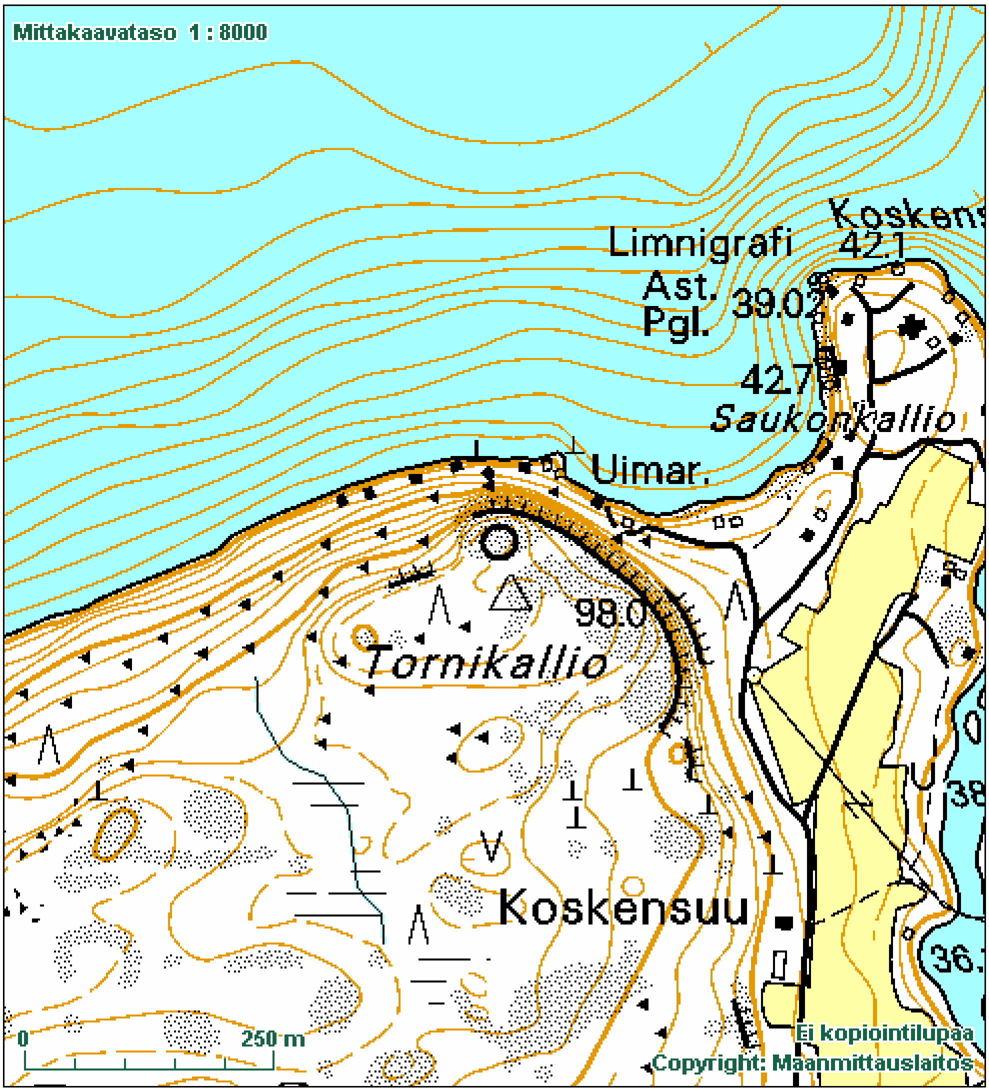
Map 32.

PUOLAKKA (12).
Topographical Map 1:8.000, Extract from database, 2003.

The site is marked on the map with a cross-circle symbol.
The core zone in map is scale a circle with diameter of 1,25 mm (in the field 10 m), and the buffer zone is marked with a parallelogram (in the field 36*25 sq. m).
(The core zone is not marked on the map).

Map 33.

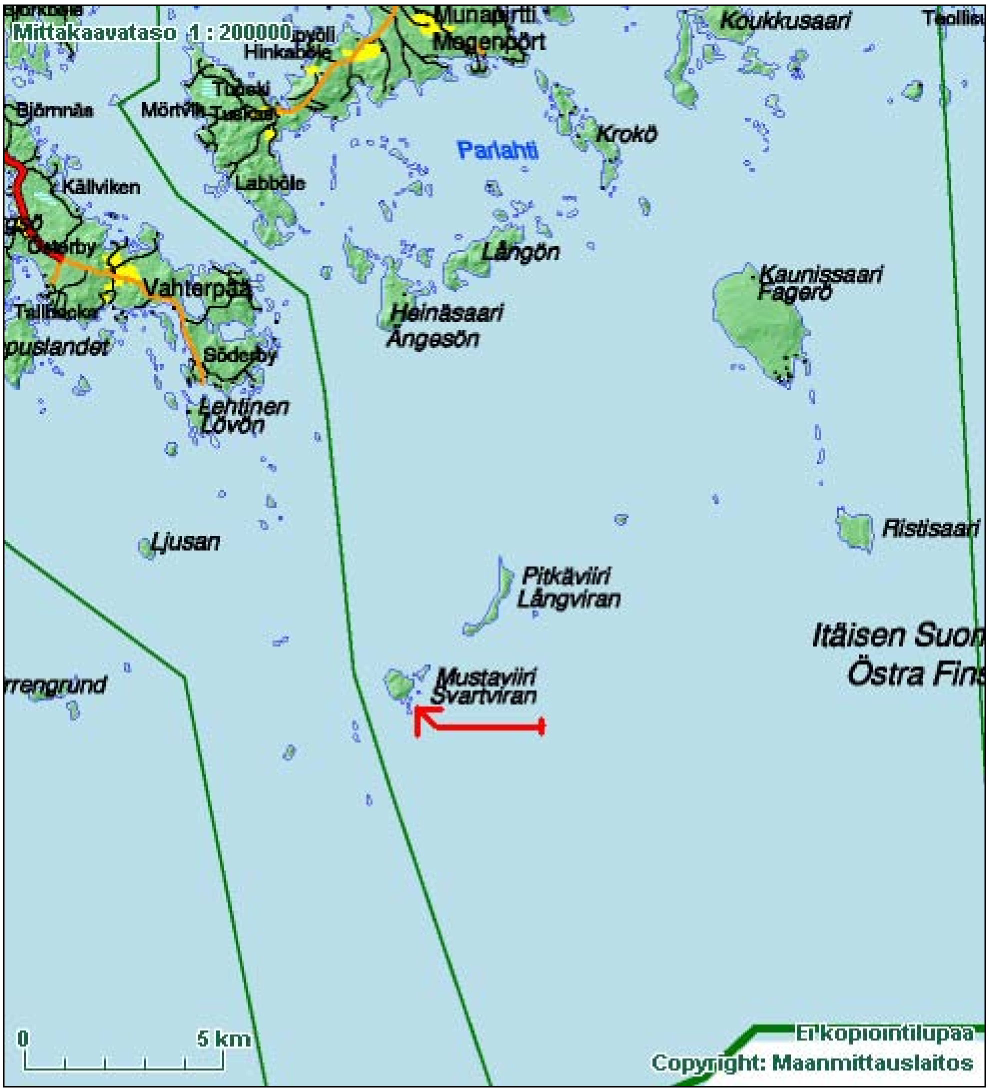
PORLOM II (13)
Topographical Map 1:80.000, Extract from database, 2003.



Map 34.

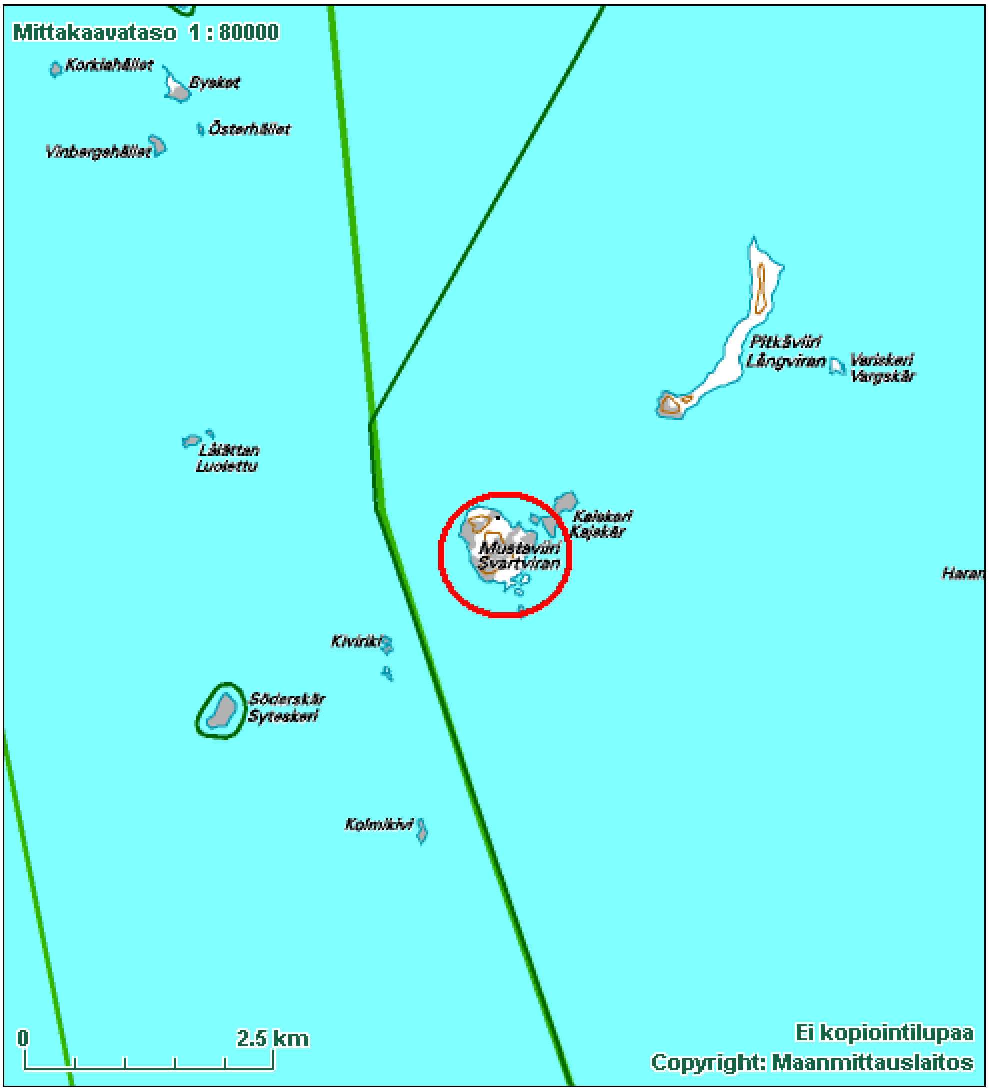
PORLOM II (13)
Topographical Map 1:8.000, Extract from database, 2003.

The site is marked on the map with a circle to NNW from a triangle.
The core zone in map scale a circle with diameter of 1,25 mm (in the field 10 m) and the buffer zone a circle with diameter of 5,0 mm (in the field 40 m).
(Zones are not marked on the map).



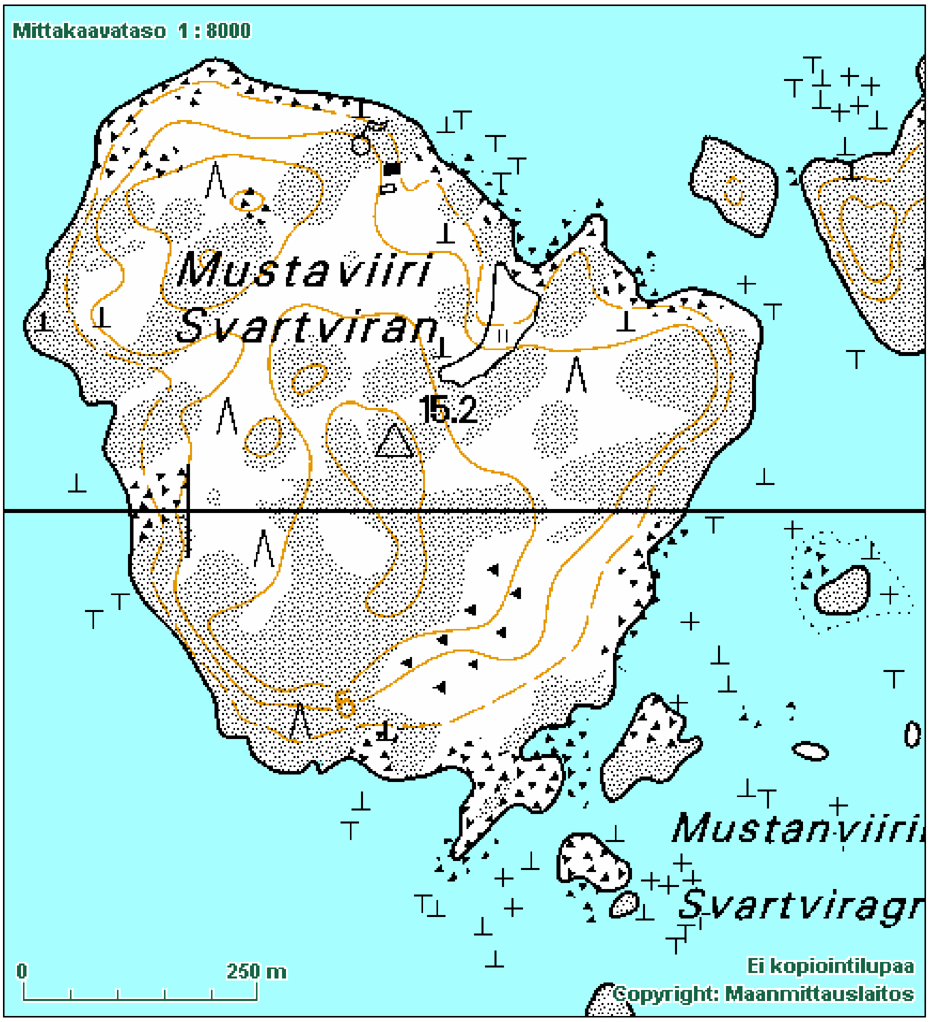
Map 35.

SVARTVIRA (14).
Topographical Map 1:200.000, Extract from database, 2003.



Map 36.

SVARTVIRA (14)
Topographical Map 1:80.000, Extract from database, 2003.



Map 37.

SVARTVIRA (14)
Topographical Map 1:8.000, Extract from database, 2003.

The site is marked on the map with a triangle.
The core zone in map scale is a circle with diameter of 1,25 mm (in the field 10 m) and the buffer zone a circle with diameter of 1,0 (in the field 80 m).
(Zones are not marked on the map).

Map 38.

MÄKI-PÄÄLYS (15) and HOGLAND, Z (16).

Administrative map of the Leningrad Region, 1:1,5 M. Aerogeodeziya, 2003.

ФЕДЕРАЛЬНАЯ СЛУЖБА ГЕОДЕЗИИ И КАРТОГРАФИИ РОССИИ

Фрагмент карты о. ГОГЛАНД. Ленинградская область.

1:25 000

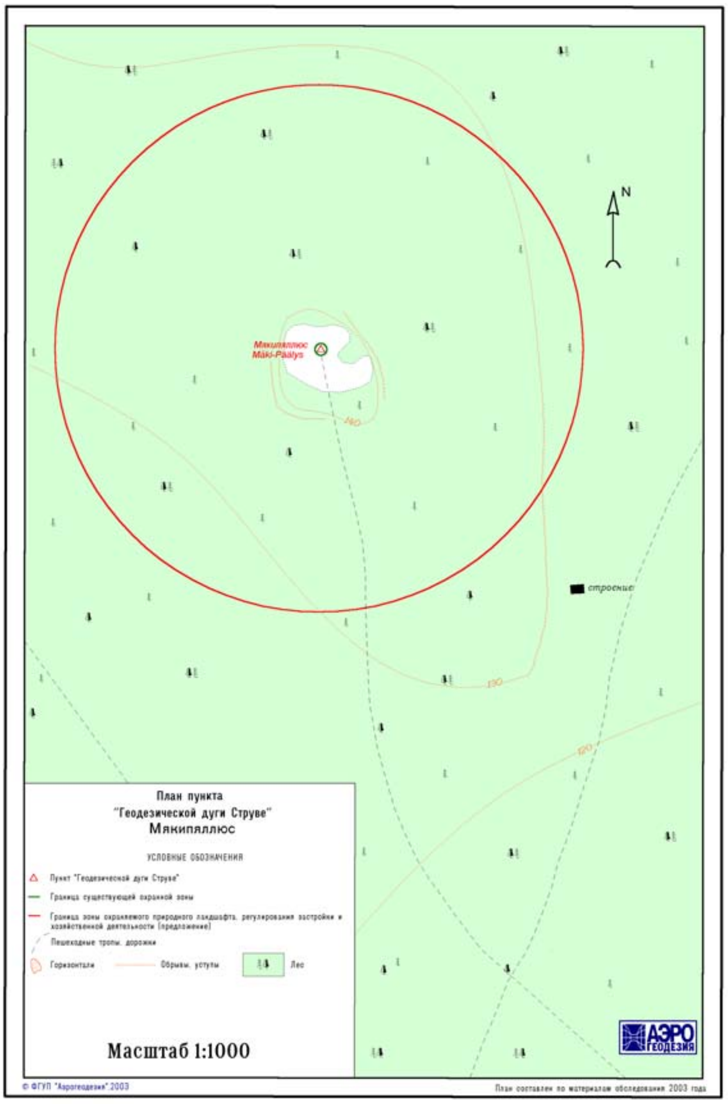
В 1 сантиметре 250 метров

- Пункты "Геодезической дуги Струве"
- Границы зон охраняемого природного ландшафта, регулирования застройки и хозяйственной деятельности (предложение)
- Пункт международной программы "Уровень Балтийского моря"
- Строения
- Навигационные знаки
- К Колодцы
- Отдельные камни
- Улучшенные грунтовые дороги
- Пешеходные тропы, дорожки
- Полевые и лесные дороги
- • 69 Отметки высот
- Лес
- Пески
- Каменистые поверхности
- Горизонтали
- Скалы
- Обрывы
- Метеостанция

АЭРО ГЕОДЕЗИЯ

Составлено по карте масштаба 1: 25000 изд. 1958 г. с использованием материалов АФС 1997 г. и обследования 2003 г., в соответствии с требованиями к информационному обеспечению объектов всемирного культурного наследия ЮНЕСКО. Основание: "Guidelines for the Preparation of Serial Nominations to the World Heritage List". WHC, February 2002, p. 2, 3.

Map 39. MÄKI-PÄÄLYS (15) and HOGLAND, Z (16).
Topographic Map, Part of the Island of Gogland, 1:25.000. Aerogeodeziya, 2003.



Map 40.

MÄKI-PÄÄLYS (15).
Topographic Plan of the site, 1:2.000. Aerogeodeziya, 2003.
(Original plan in the scale 1:1.000)

The core zone is marked with small circle (diameter 2,65 m in the field) and the buffer zone with larger circle (diameter 140 m in the field).

Map 41.

HOGLAND, Z
Topographic Plan of the site, 1:2.000. Aerogeodeziya, 2003.
(Original plan in the scale 1:1000)

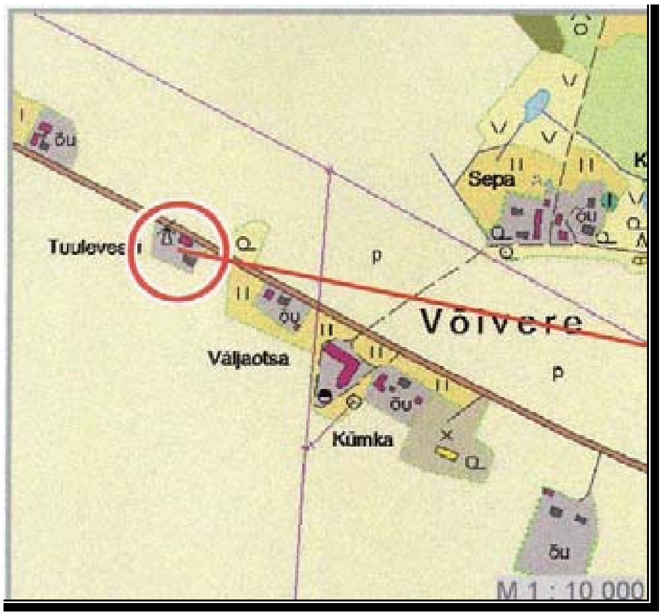
The core zone is marked with small circle (diameter 4,0 m in the field) and the buffer zone with larger circle (diameter 140 m in the field).

Map 42.

WOIBIFER (17), KATKO (18) and DORPAT (19).
Estonian Schematic Map, 1:2,6 M. Estonian Land Board, 2003.
(Original map in scale 1:1,3 M)

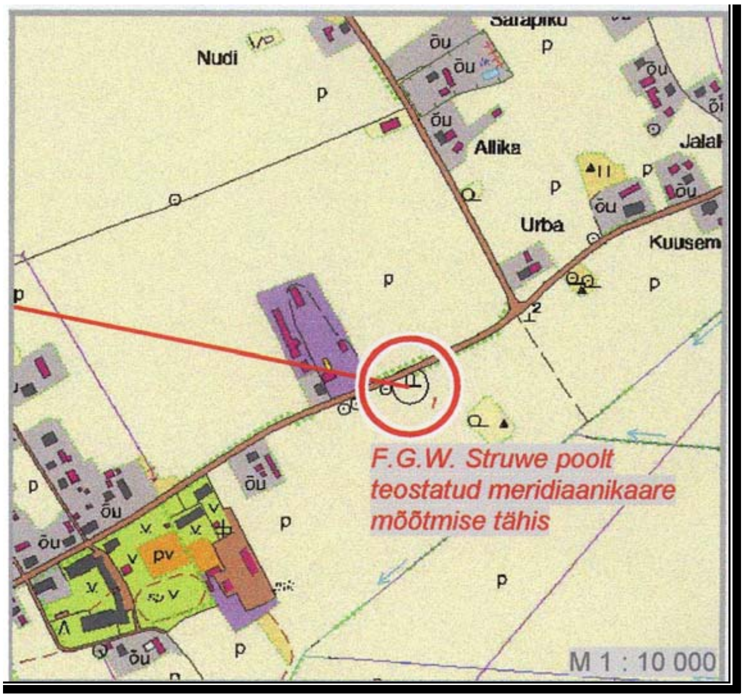
Map 43.

WOIBIFER (17) and KATKO (18).
Voivere-Simuna area Topographic Map, 1:100.000. Estonian Land Board, 2003.
Simuna baseline terminals, (Original map in scale 1:50.000)
The maps in the upper corners are in the scale 1:20.000, (in original 1:10.000).



Map 44.

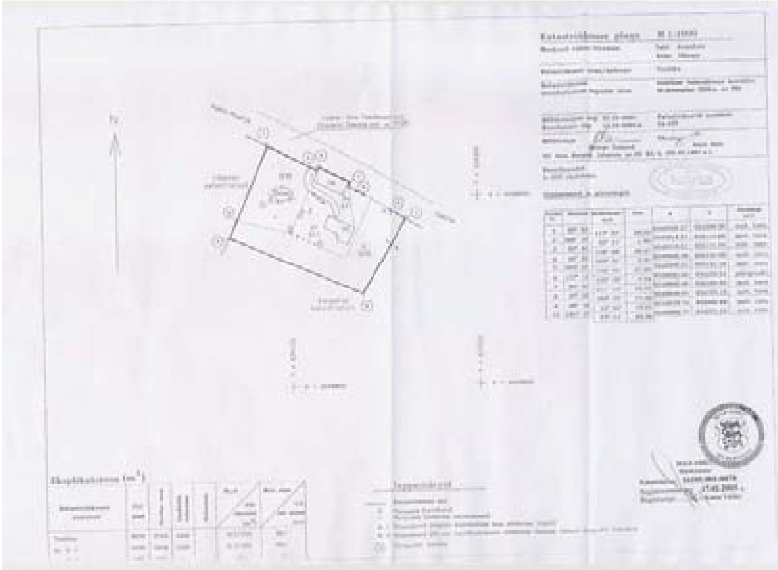
WOIBIFER (17).
Voivere-Simuna area Topographic Map, 1:10.000. Estonian Land Board, 2003.
Simuna baseline NW terminal.



Map 45.

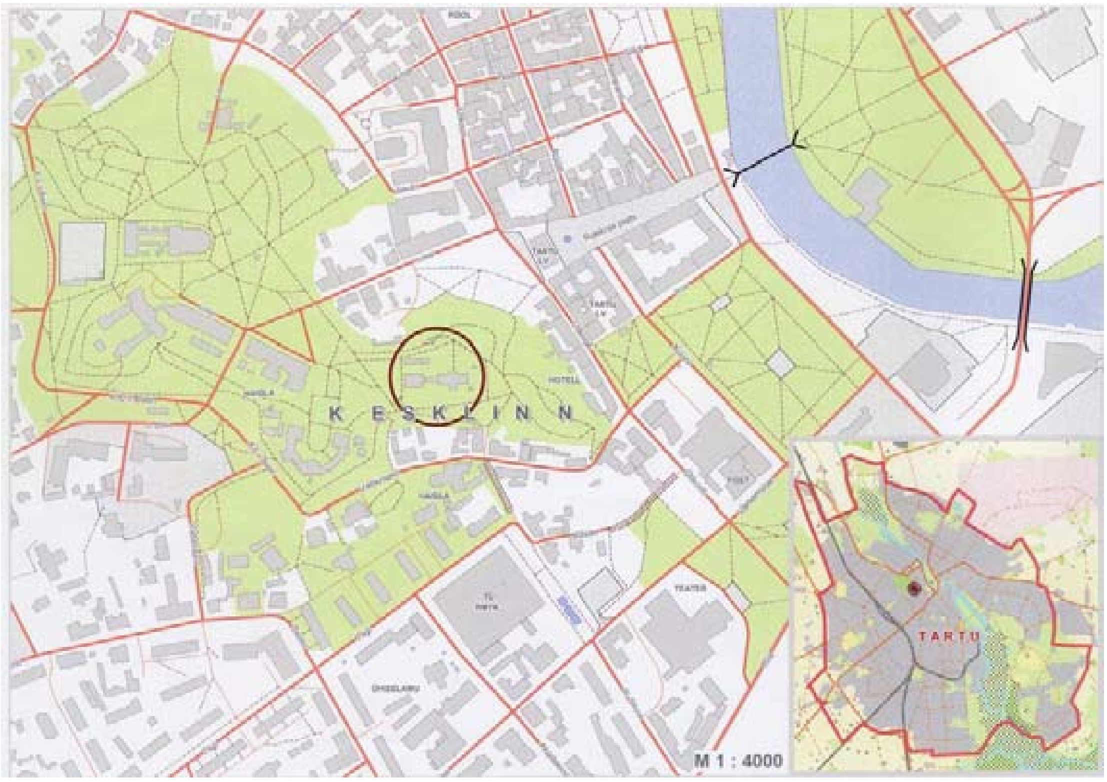
KATKO (18).
Voivere-Simuna area Topographic Map, 1:10.000. Estonian Land Board, 2003.
Simuna baseline SE terminal.

WOIBIFER and KATKO:
In the map scale the core zones have a diameter of 1,13 mm (in the field 11,3 m) and for buffer zone 8 mm (80 m) respectively.
(The zones are not marked on the maps.)



Map 46.

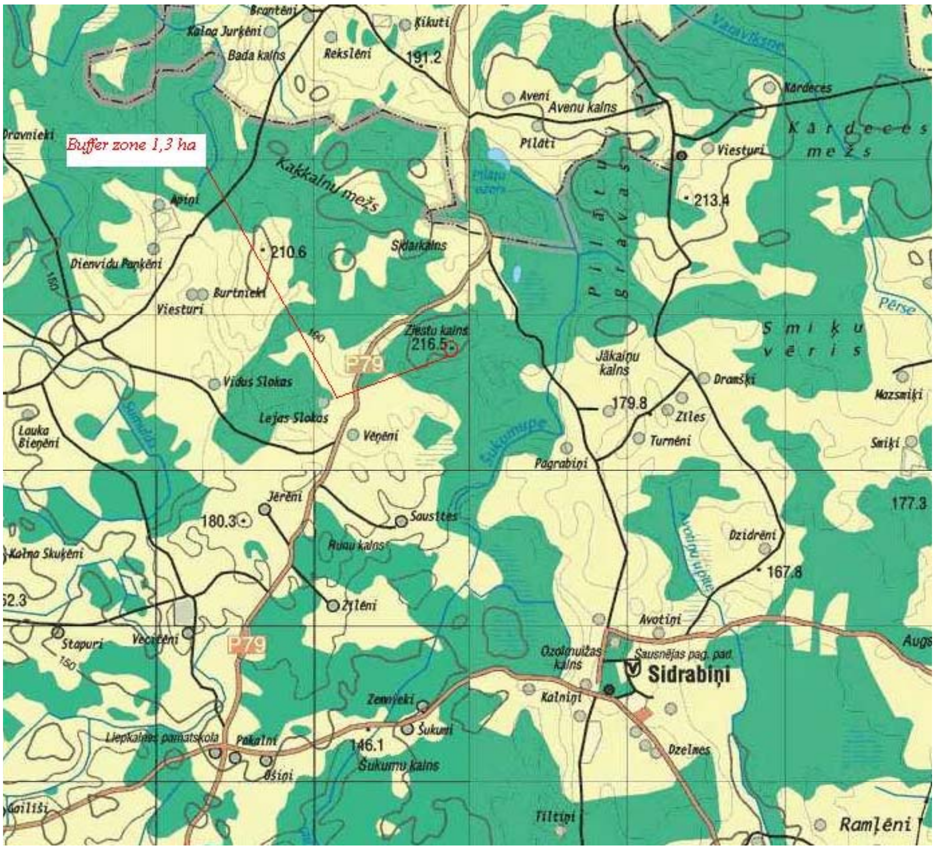
WOIBIFER (17).
Cadastral Map, 1:4.000. Estonian Land Board, 2003.
(Original map in scale 1:1.000)
Simuna baseline NW terminal.



Map 47.

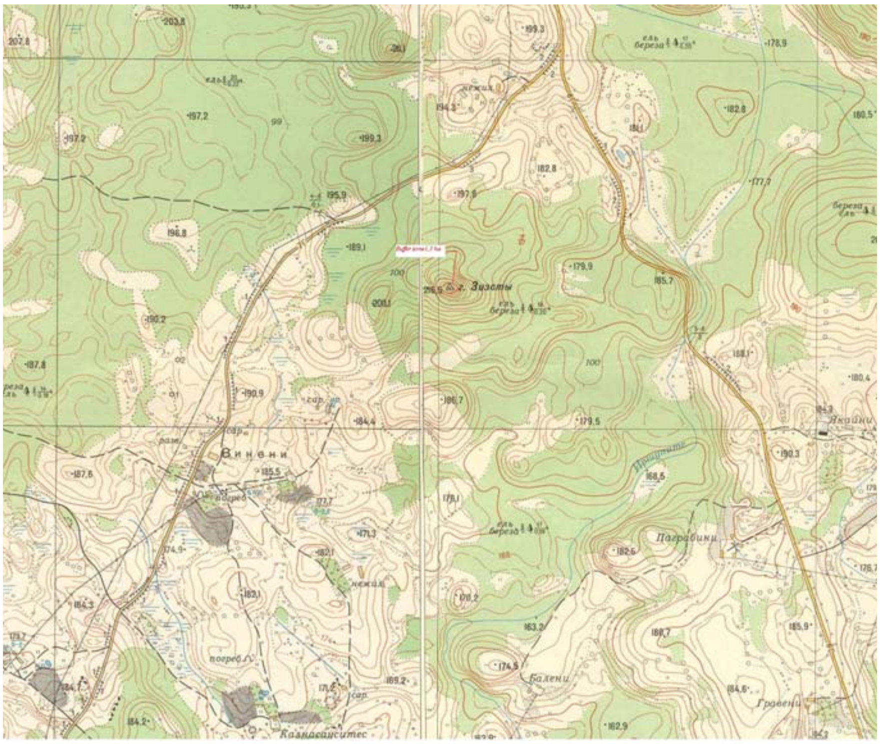
DORPAT (19).
Tartu City Map, 1:8.000. Estonian Land Board, 2003. (Original map in scale 1:4.000)

The site is on the centre of the cross-shaped Observatory building.
The core zone area is that of the foundation of the Observatory building and
the buffer zone is in map scale a circle with a diameter of 10 mm (in the field 80 m).
(The buffer zone is not marked on the map)



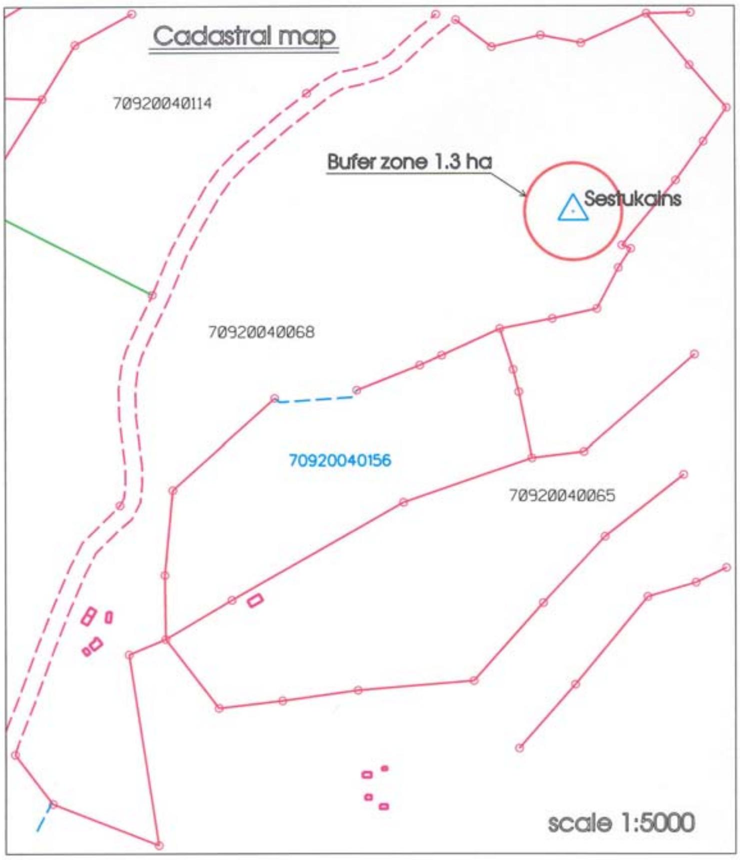
Map 48.

SESTU-KALNS (20).
State Satellite Map, 1:50.000. State Land Service of Latvia,1998.



Map 49

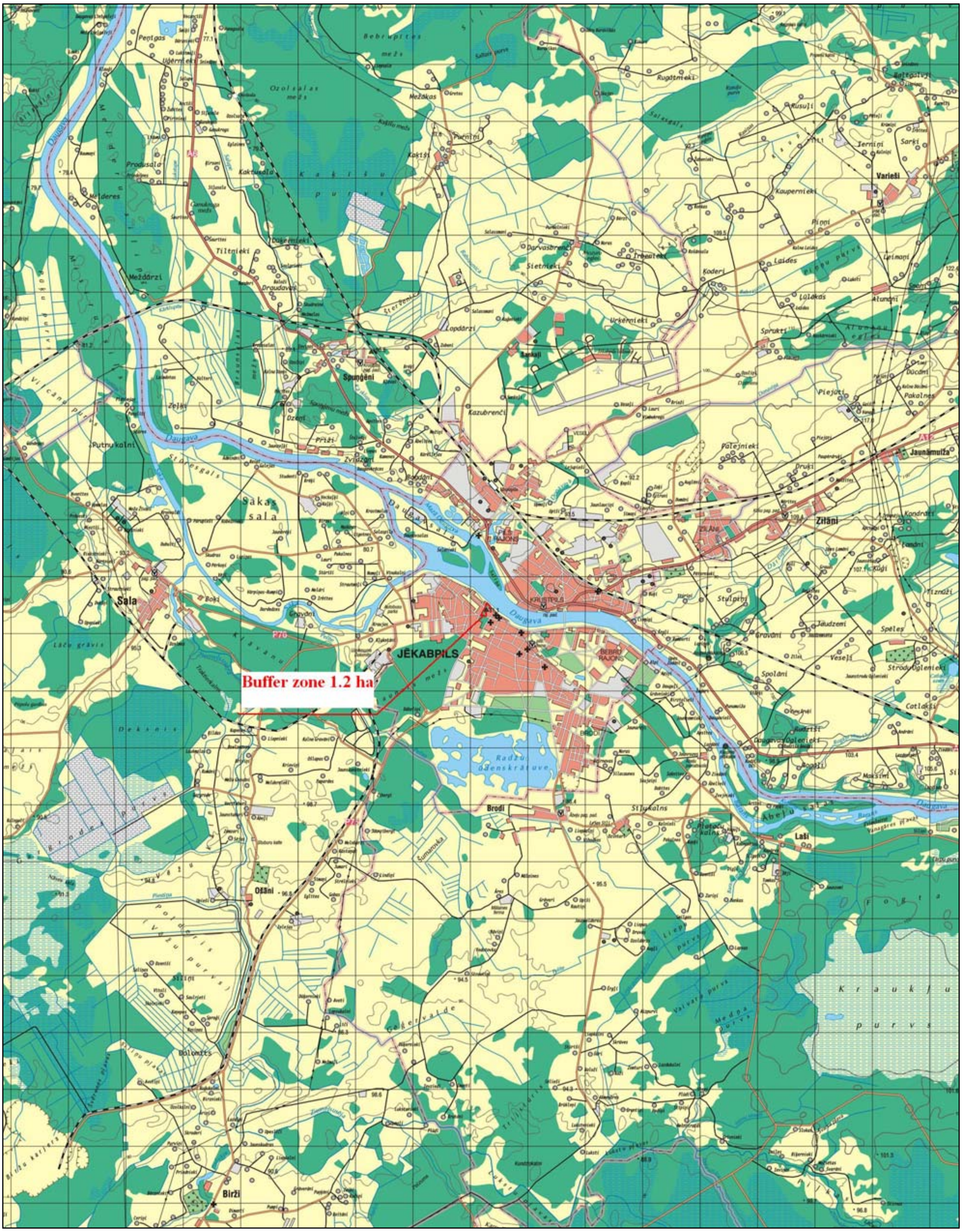
SESTU-KALNS (20).
State Topographic Map, 1:20.000. State Land Service of Latvia, 1974.
(Original map scale 1:10.000)



Map 50.

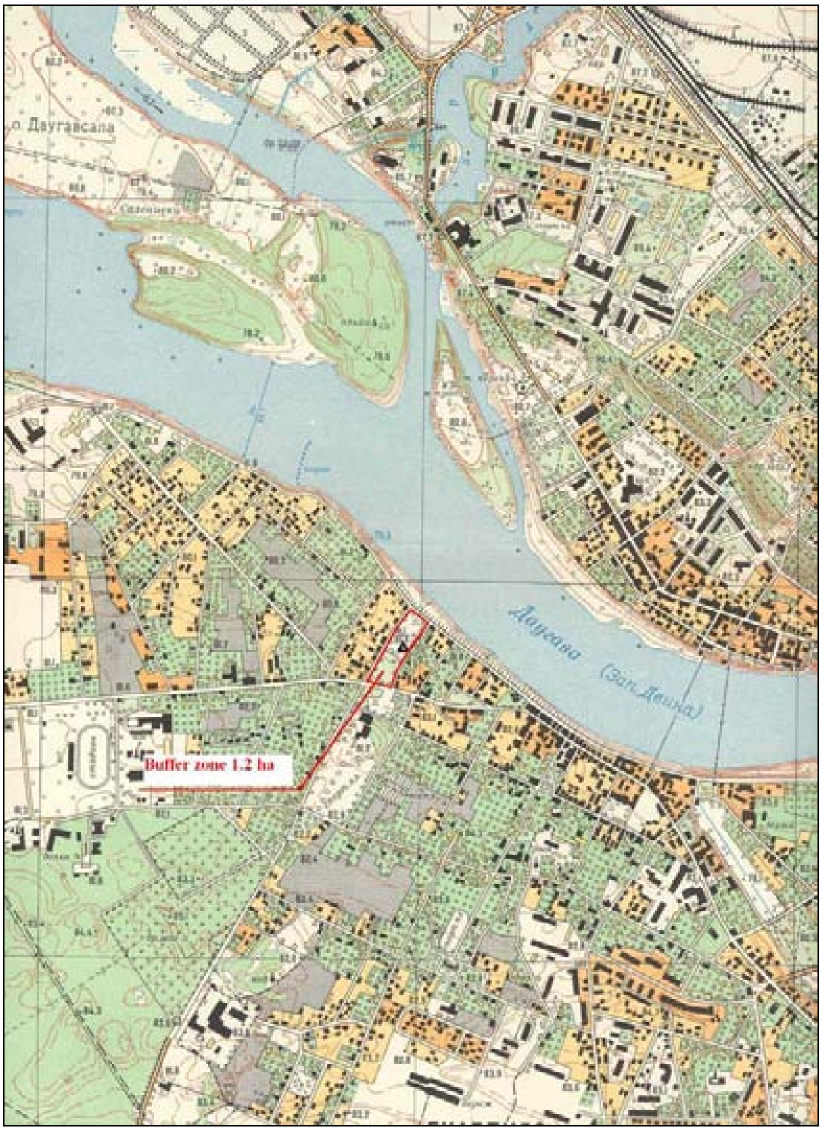
SESTU-KALNS (20).
Cadastral Map, 1:10.000. State Land Service of Latvia, 2001.
(Original Scale 1:5.000).

In the map scale the core zone has a diameter of 1,13 mm (in the field 11,3 m).
The buffer zone is marked with a circle on the map (diameter in the field 128,7 m).
(The core zone is not marked on the map.)



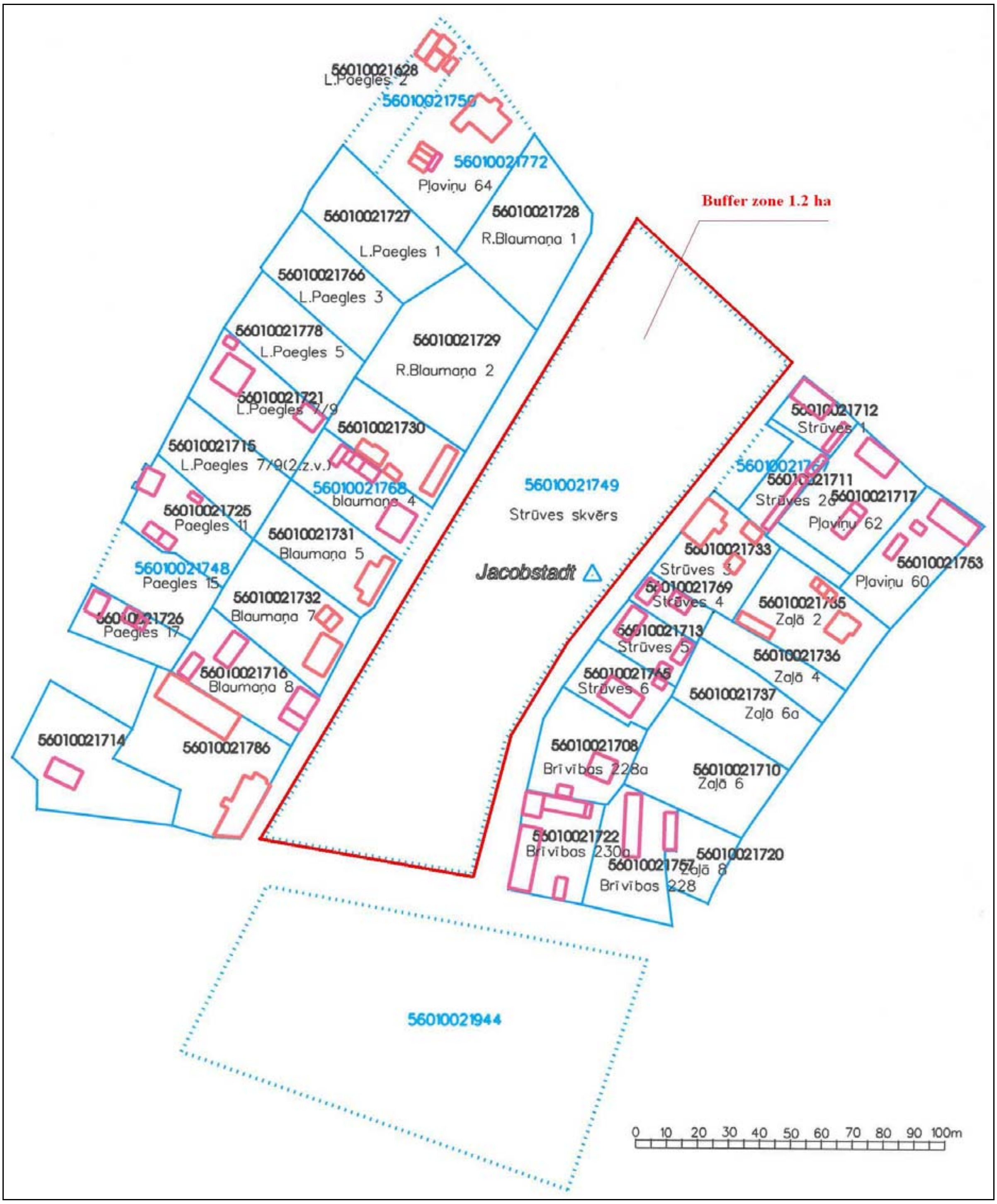
Map 51.

JACOBSTADT (21).
State Satellite Map, 1:50.000. State Land Service of Latvia,1998.



Map 52.

JACOBSTADT (21).
State Topographic Map, 1:20.000. State Land Service of Latvia, 1974.
(Original map scale 1:10.000)



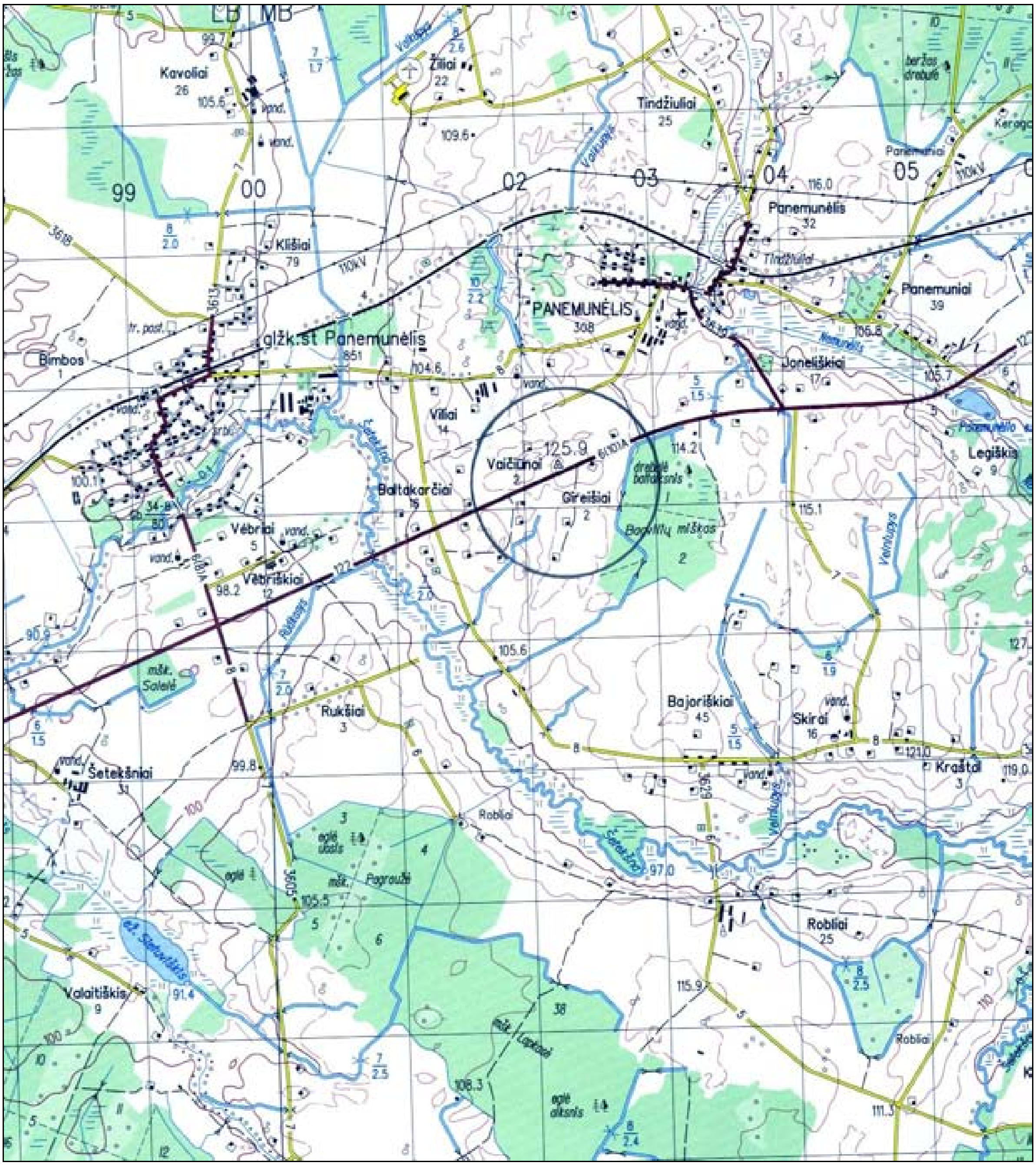
Map 53.

JACOBSTADT (21).
Cadastral Map, Scale 1:2.000. State Land Service of Latvia, 2002.

In the map scale the core zone is a circle with diameter of 0,8 mm (in the field 1,6 m).
On the map has been marked the buffer zone that is the area of "The Struve Park".

Map 54.

KARISCKI (22).
Topographic Map, Scale 1:200.000. Map sheet N-35-II.
Lithuanian State Service of Land Survey and Geodesy, 1994.



Map 55.

KARISCKI (22).
Topographic Map, Scale 1:50.000. Map sheet N-35-3-AB.
Lithuanian State Service of Land Survey and Geodesy, 1999.

Map 56.
(On the next page.)

KARISCKI (22).
Site description and map, for the geodetic site. (See next page.)

The core zone is a circle with diameter of 11,3 m in the field (not marked on the map) and the buffer zone 35,7 m similarly.

VILNIUS GEDIMINAS TECHNICAL UNIVERSITY
GEODETIC INSTITUTE

GPS SECOND ORDER STATION
GIREIŠIAI
75S-0045

Co-ordinates
(LKS 94 Co-ordinate system, GPS measurements, 1996):

B = **55°54′08,67973″**	x(N) = **6 197 390,788 m**
L = **25°26′12,41877″**	y(E) = **589 849,167 m**

H_e = **147,912 m**

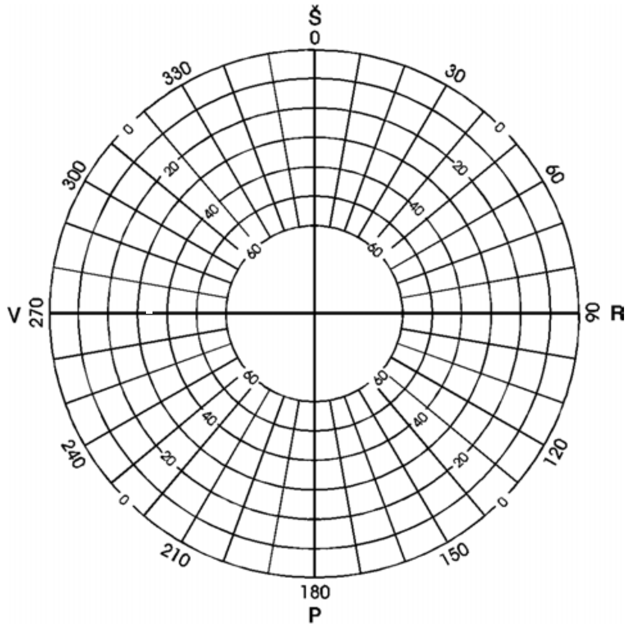
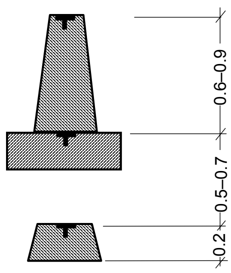
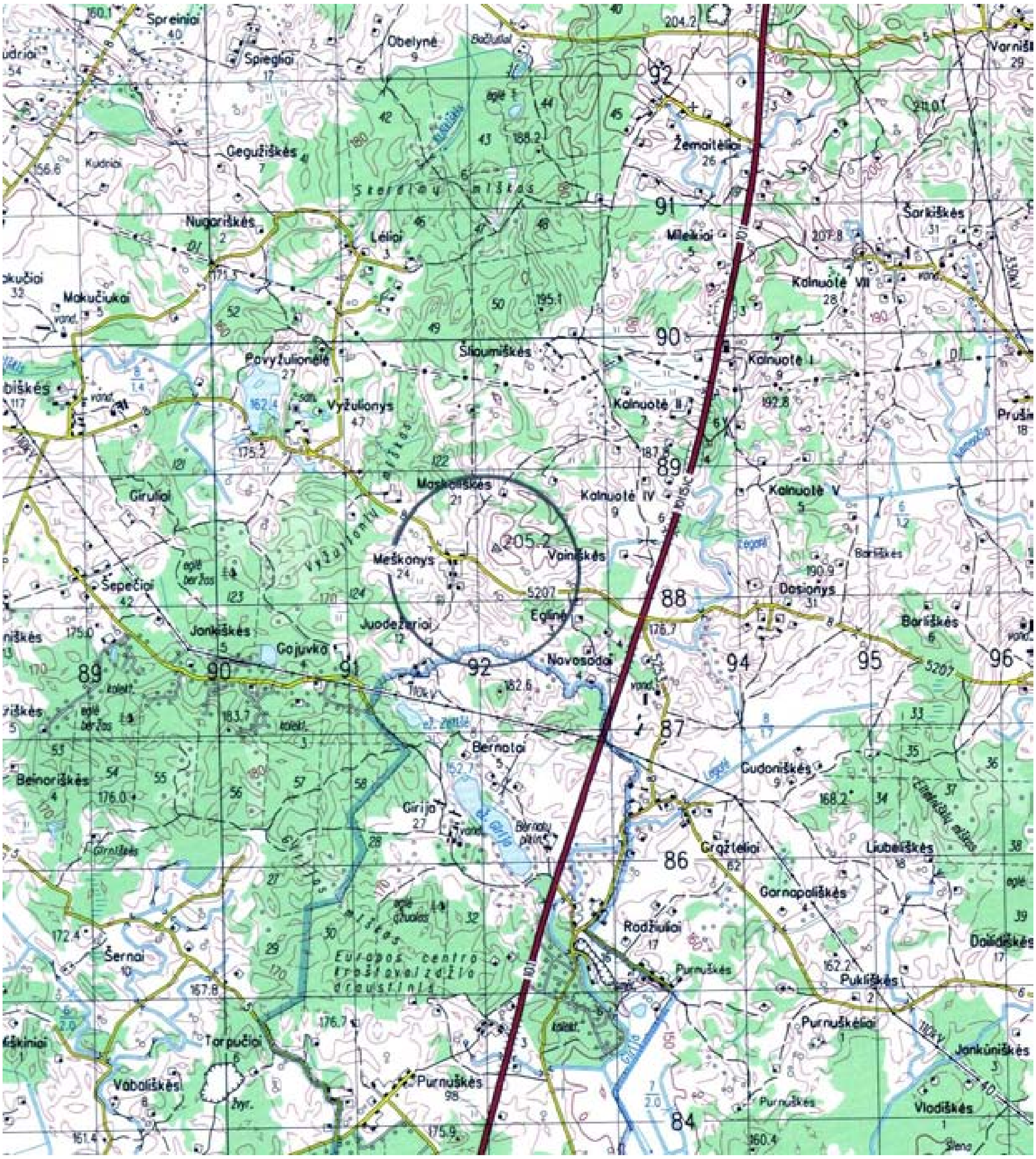
LOCATION	VISIBILITY
	
1:10 000	i = 1,75 m

PHOTO	SKETCH OF MONUMENT
	
	Monument type 41

The station is situated in the Lithuania, Rokiškis district, municipality of Panemunėlis, Gireišiai village, about 3 km to east from the road Panemunėlis–Salos (10.1 km to the west from the intersection to Rokiškis), 60 m to north-east from the road, on the hill.
Described by B. Krikštaponis, 1996 04

Map 57.

MESCHKANZI (23).
Topographic Map, Scale 1:200.000. Map sheet N-35-VIII.
Lithuanian State Service of Land Survey and Geodesy, 1995.



Map 58

MESCHKANZI (23). Topographic Map, Scale 1:50.000. Map sheet N-35-39-AB.
Lithuanian State Service of Land Survey and Geodesy, 1998.

Map 59.
(On the next page.)
‘
MESCHKANZI (23)
Site description and map for the geodetic site. (See next page.)

The core zone is a circle with diameter of 11,3 m in the field (not marked on the map)
and the buffer zone 35,7 m similarly.

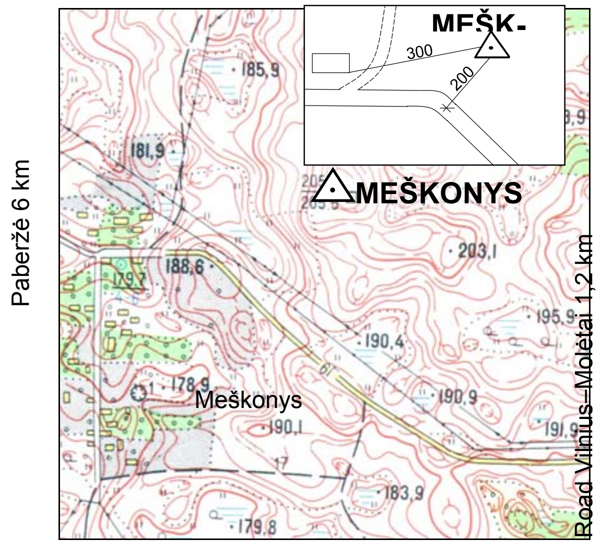
VILNIUS GEDIMINAS TECHNICAL UNIVERSITY
GEODETIC INSTITUTE

GPS ZERRO ORDER STATION
MEŠKONYS
73S-0312

Co-ordinates
(LKS 94 Co-ordinate system, GPS measurements, 1992):

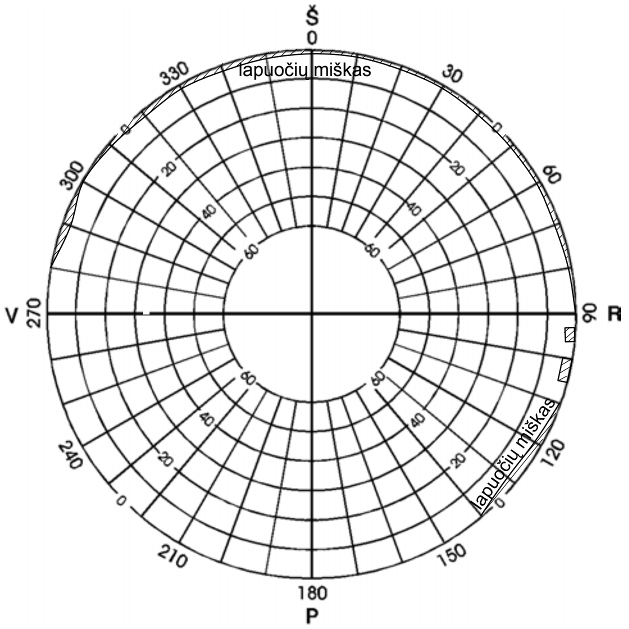
B = 54°55′51,38821″ **x(N) = 6 089 118,304 m**
L = 25°19′00,31622″ **y(E) = 584 389,823 m**
H_e = 229,515 m

LOCATION



1:10 000

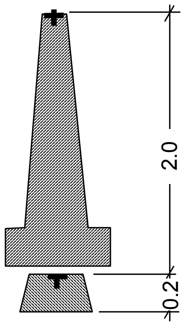
VISIBILITY



i = 1,80 m

PHOTO

SKETCH OF MONUMENT

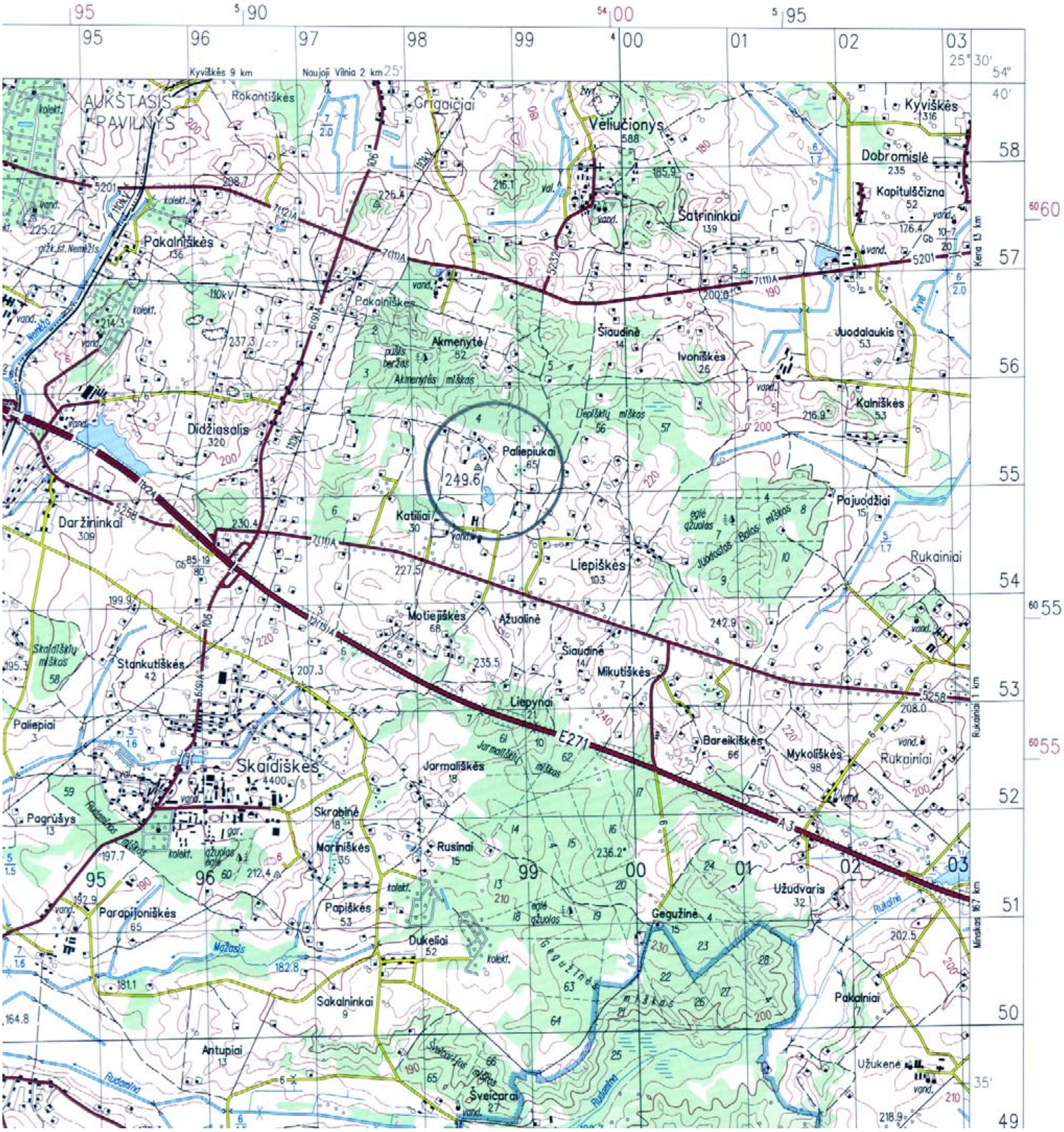


Monument type G – 04

The station is situated in the Lithuania, Vilnius district, municipality of Nemenčinė, eastern part of Meškonys village, about 0,2 km to north from the road Nemenčinė–Meškonys.
Described by B. Krikštaponis, 1992 06

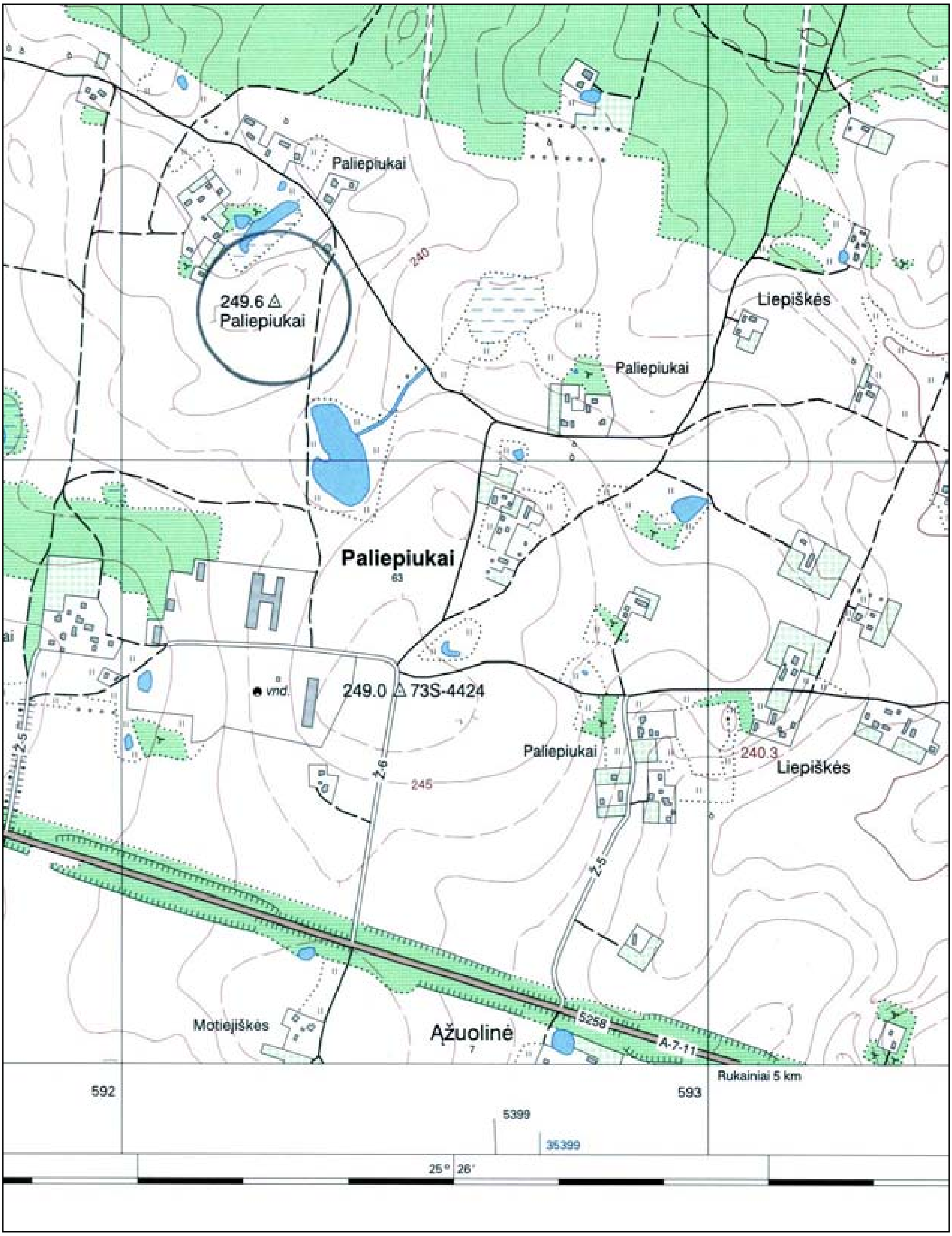
Map 60.

BERESNÄKI (24).
Topographic Map, Scale 1:200.000. Map sheet N-35-XIV.
Lithuanian State Service of Land Survey and Geodesy, 1994.



Map 61.

BERESNÄKI (23).
Topographic Map, Scale 1:50.000. Map sheet N-35-51-AB.
Lithuanian State Service of Land Survey and Geodesy, 1999.



Map 62.

BERESNÄKI (23).
Topographic Map, Scale 1:10.000. Map sheet 78/31.
Lithuanian State Service of Land Survey and Geodesy, 1999.

Map 63.
(On the next page.)
BERESNÄKI (23). Site description and map, for the geodetic site. (See next page.)
The core zone is a circle with diameter of 11,3 m in the field (not marked on the map)
and the buffer zone 35,7 m similarly.

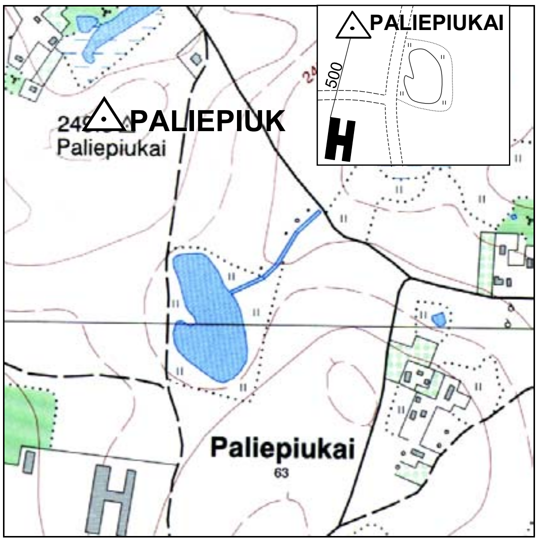
VILNIUS GEDIMINAS TECHNICAL UNIVERSITY
GEODETIC INSTITUTE

GPS SECOND ORDER STATION
PALIEPIUKAI
73S57196

Co-ordinates
(LKS 94 Co-ordinate system, GPS measurements, 1995):

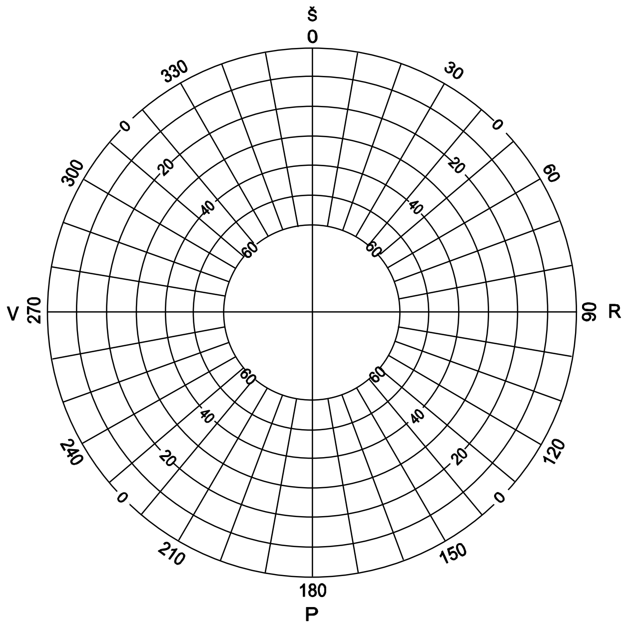
B = 54°38′03,93060″ **x(N) = 6 056 261,508 m**
L = 25°25′44,66230″ **y(E) = 592 260,273 m**
H_e = 274,695 m

LOCATION



1:10 000

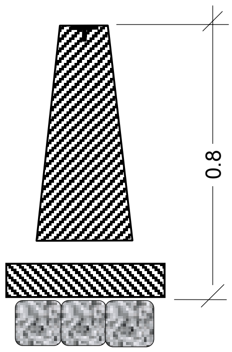
VISIBILITY



i = 2,11 m

PHOTO

SKETCH OF MONUMENT

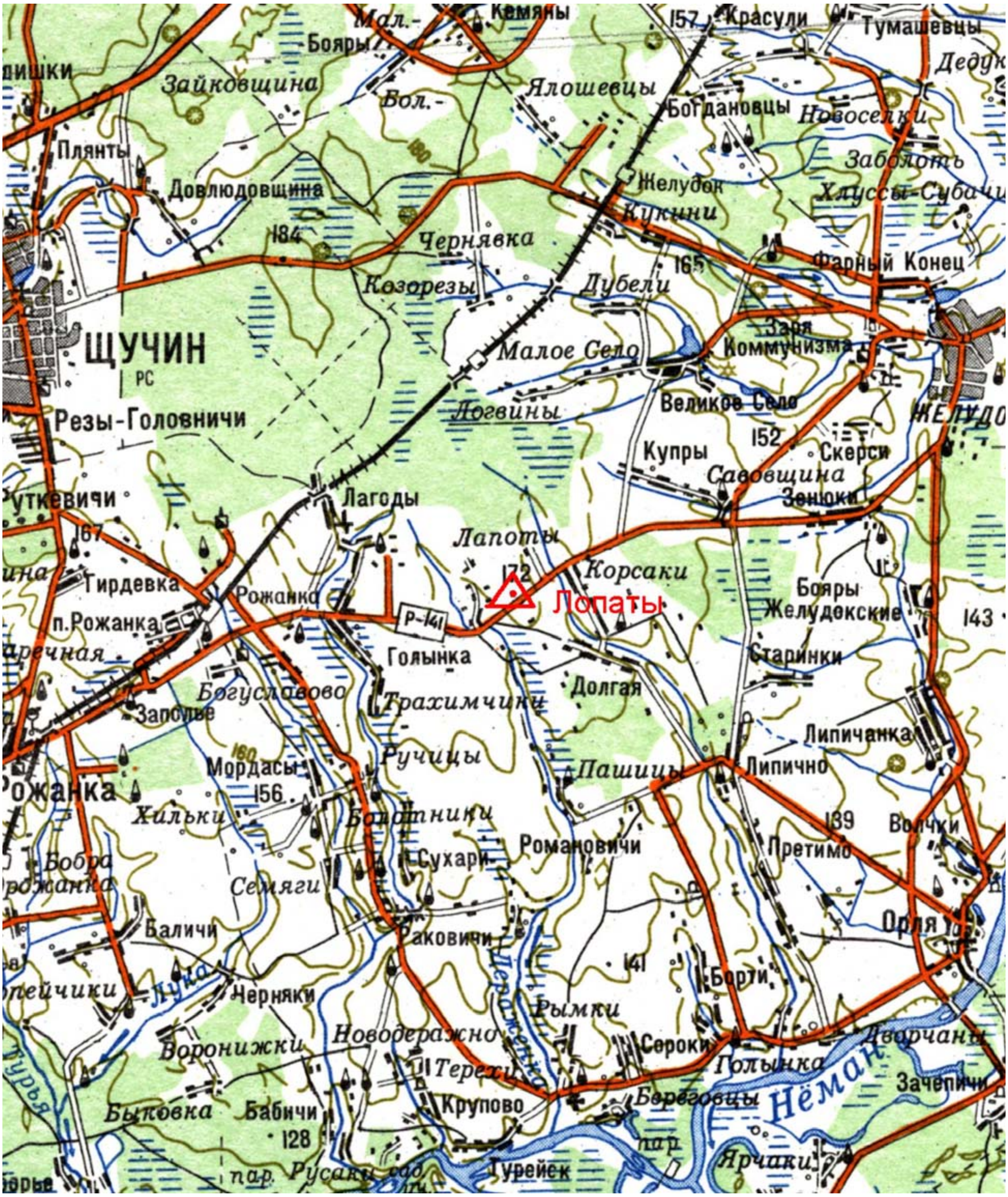


The station is situated in the Lithuania, Vilnius district, municipality of Nemėžis, near Paliepiukai village, about 1,2 km to north from the road Vilnius–Minsk.
Described by P. Viskontas, 2003 10
Described by R. Lučiūnas, 1990 12

Map 64.

TUPISCHKI (24).
Topographic Map, 1:100.000. Map Sheet N-35-XIX.
Committee for Land Resources, Geodesy and Cartography under the
Council of Ministers of the Republic of Belarus, 2002.
(Original map scale 1:200.000).

The core zone is a circle with diameter of 5,4 m and the buffer zone 11,3 m similarly.
(Zones are not showed on the map.)



Map 65.

LOPATI (25).
Topographic Map, 1:100.000. Map Sheet N-35-XIX.
Committee for Land Resources, Geodesy and Cartography under the
Council of Ministers of the Republic of Belarus, 2002.
(Original map scale 1:200.000)

The core zone is a circle with diameter of 5,4 m and the buffer zone 11,3 m similarly.
(Zones are not showed on the map.)

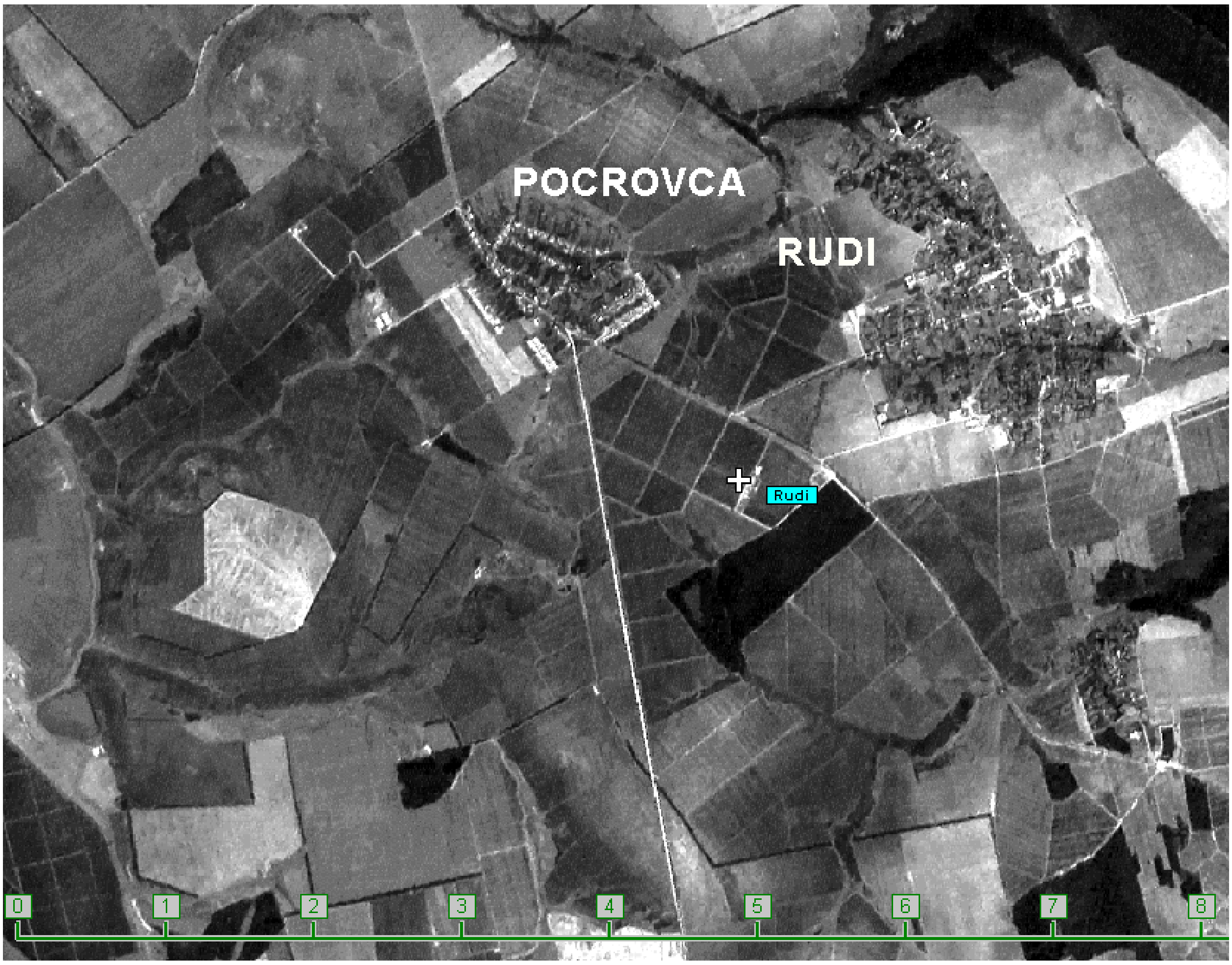
Map 66.

OSSOWNITZA (26), TCHEKUTSK (27) and LESKOWITSCHI (28).
Topographic Map, 1:200.000. Map Sheet N-35-XXXII.
Committee for Land Resources, Geodesy and Cartography under the
Council of Ministers of the Republic of Belarus, 2002.

For all above three sites in the field
the core zone is a circle with diameter of 5,4 m and the buffer zone 11,3 m similarly.
(Zones are not showed on the map.)

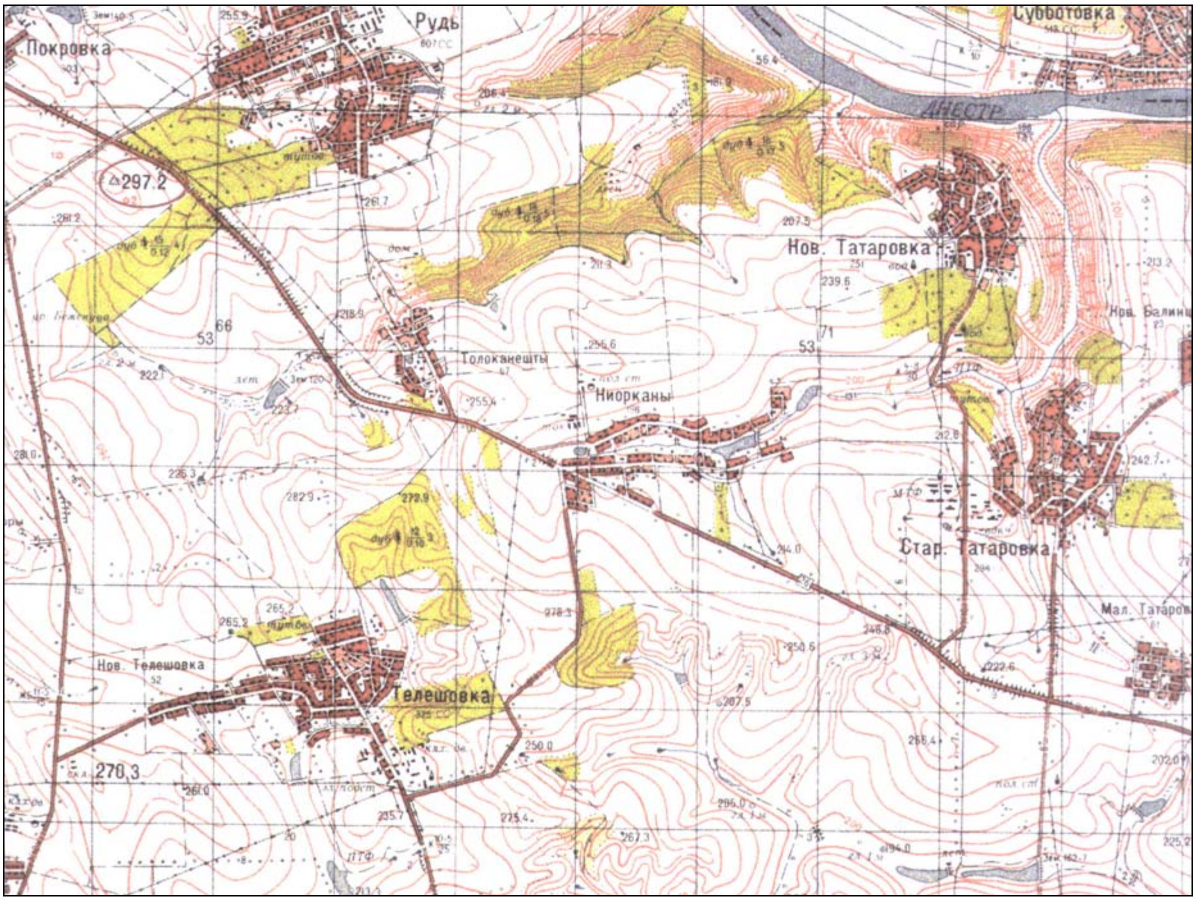
Map 67.

RUDY (30).
Topographical Map, 1:100.000.
The site is marked with a triangle on the top of the map (the hight spot value “297,2”is nearby).



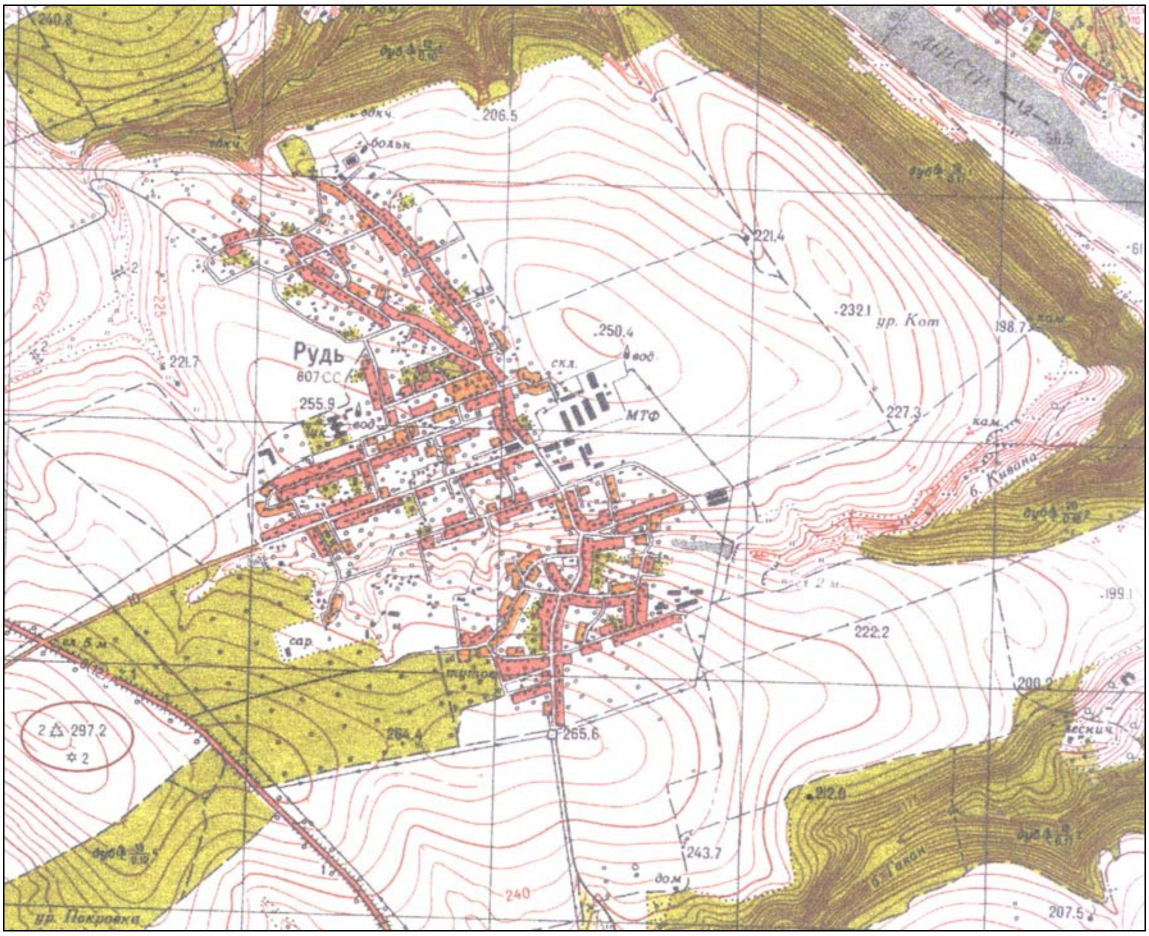
Map 68.

RUDY (30).
Aerial Photography Map, 1:50.000.



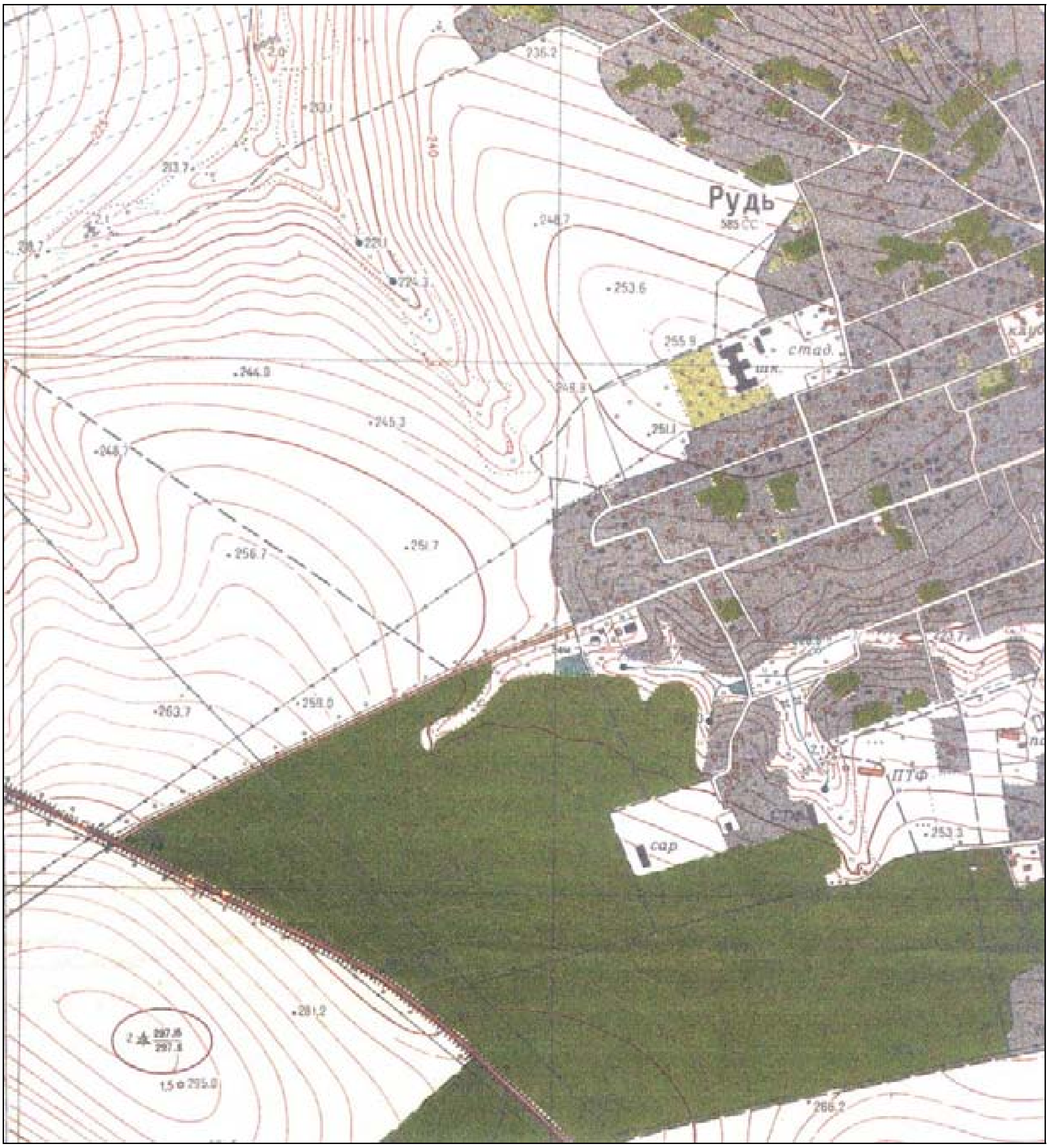
Map 69.

RUDY (30).
Topographical Map, 1:50.000.
The site is marked with a triangle on the top of the map (the hight spot value “297,2”is nearby).



Map 70.

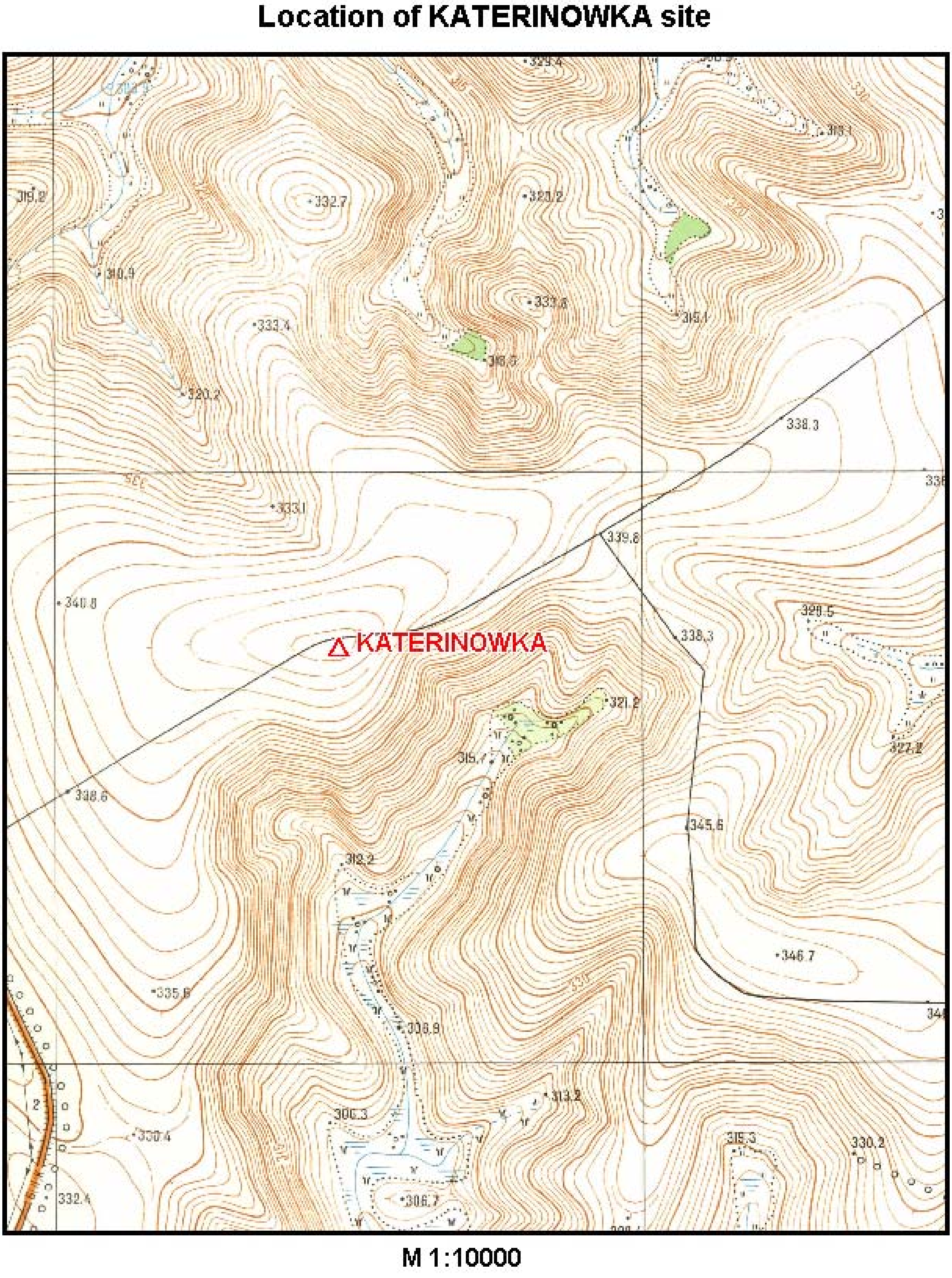
RUDY (30).
Topographical Map, 1:25.000.



Map 71.

RUDY (30).
Topographical Map, 1:10.000.
The site is marked with an ellipse on the lower left corner of the map.

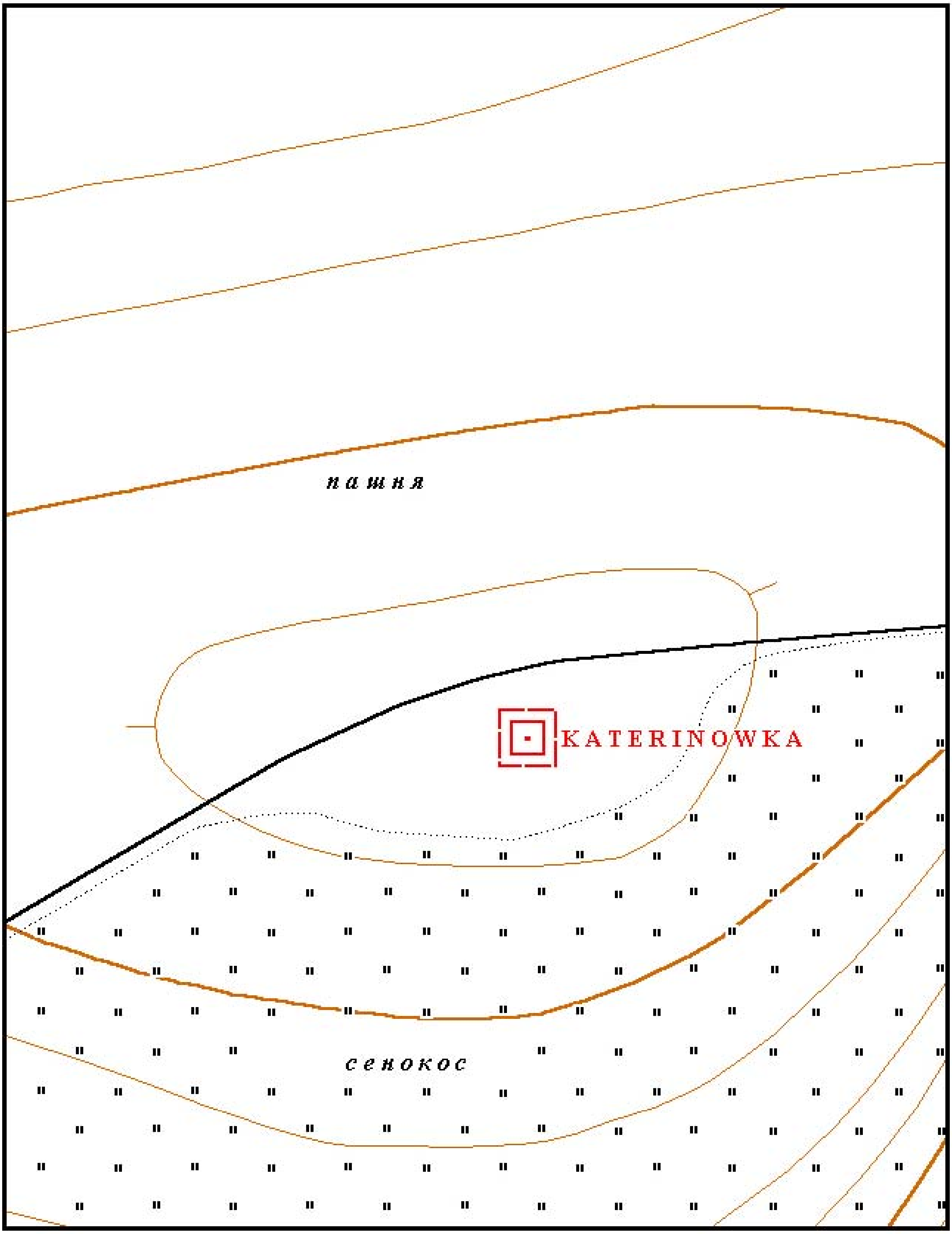
In the field the core zone is a circle with diameter of 5,4 m (not marked on the map)
and the buffer zone 35,7 m similarly.



Map 72.

KATERINOWKA (31).
Location Map, 1:10.000.

Location of KATERINOWKA site

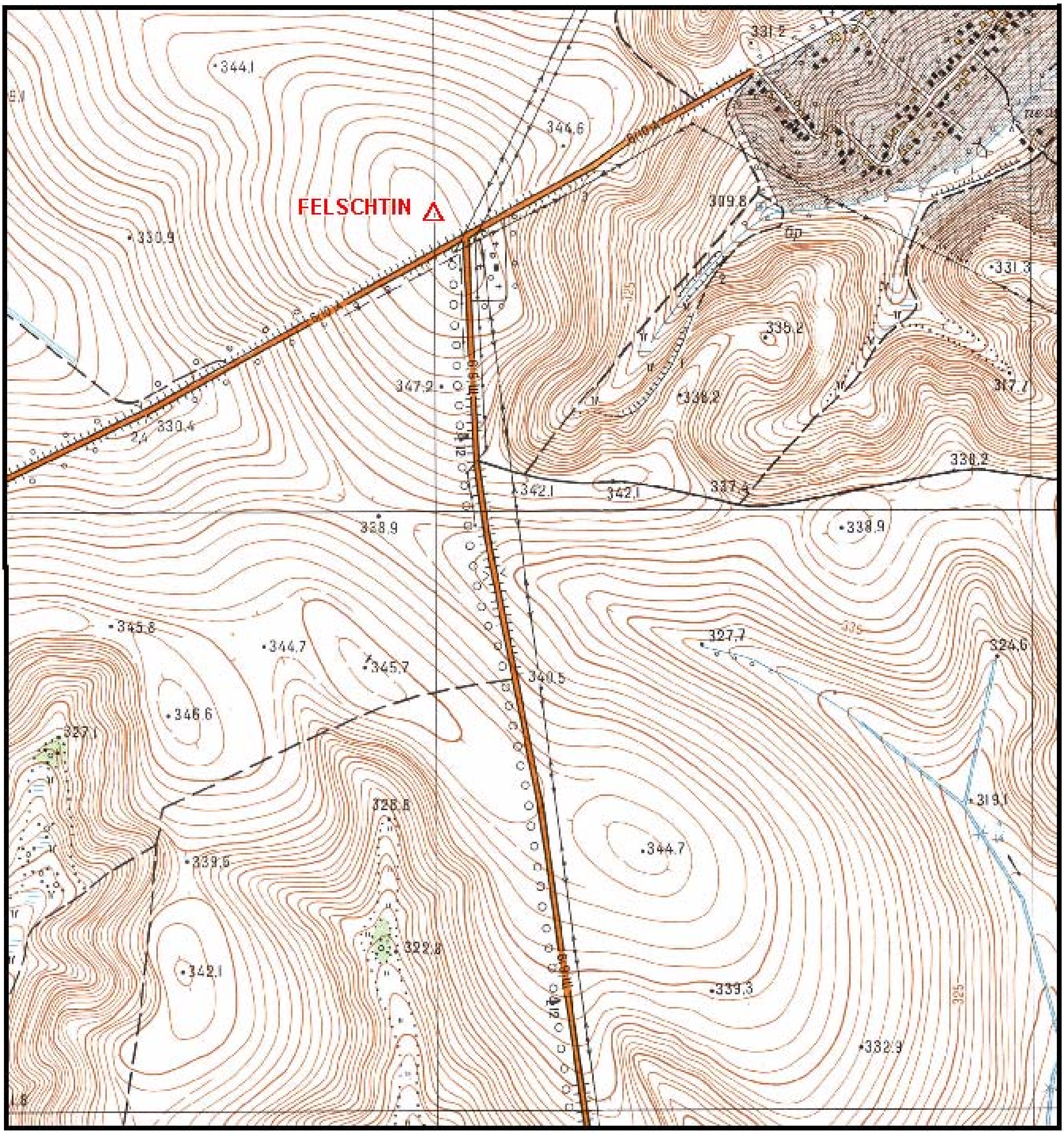


M 1:1000

Map 73.

KATERINOWKA (31). Location Map, 1:1.000.
The core zone 6*6 sq. m and the buffer zone 10*10 sq. m are shown on the map.

Location of FELSCHTIN site

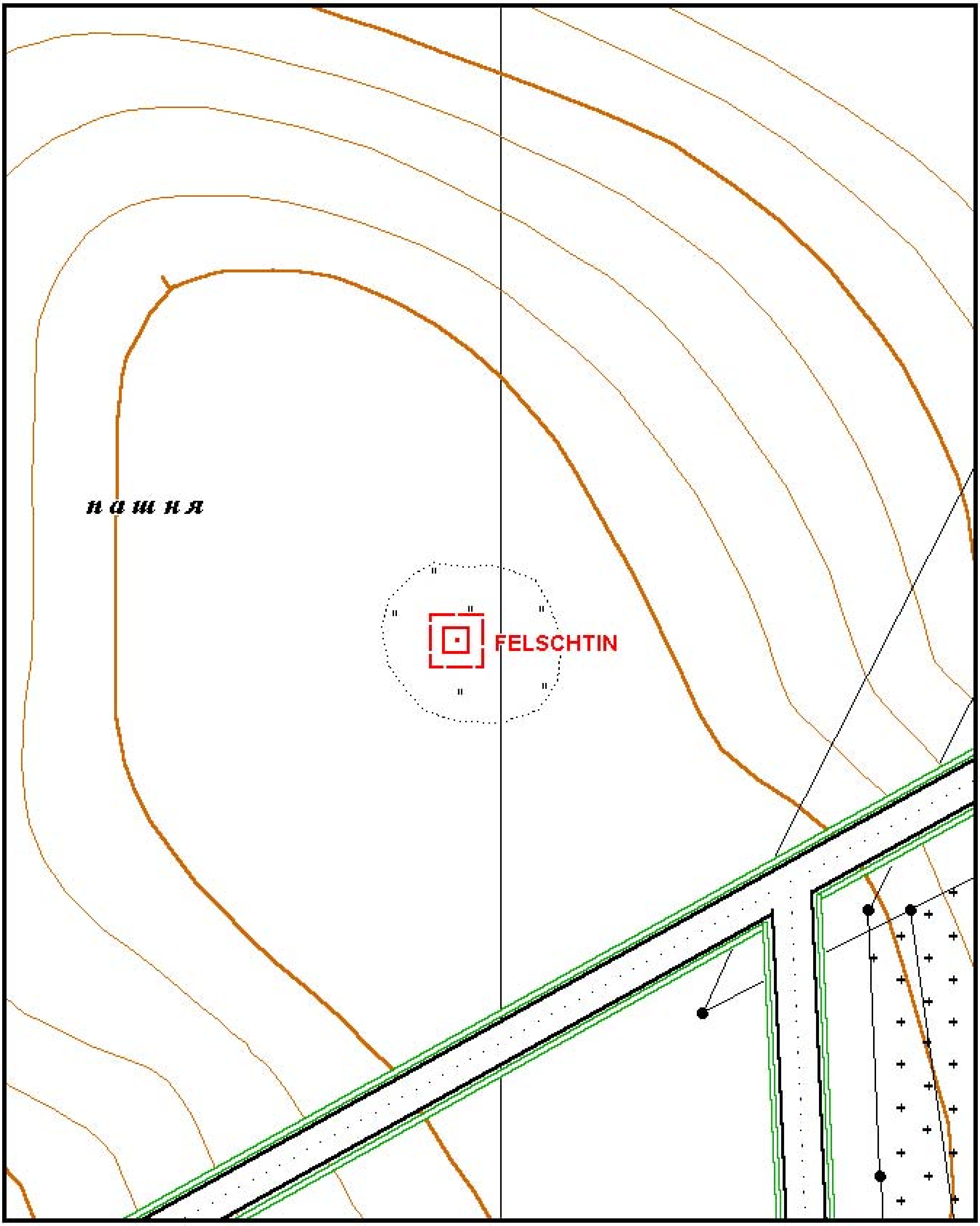


M 1:10000

Map 74.

FELSCHTIN (32).
Location Map, :10.000.

Location of FELSCHTIN site

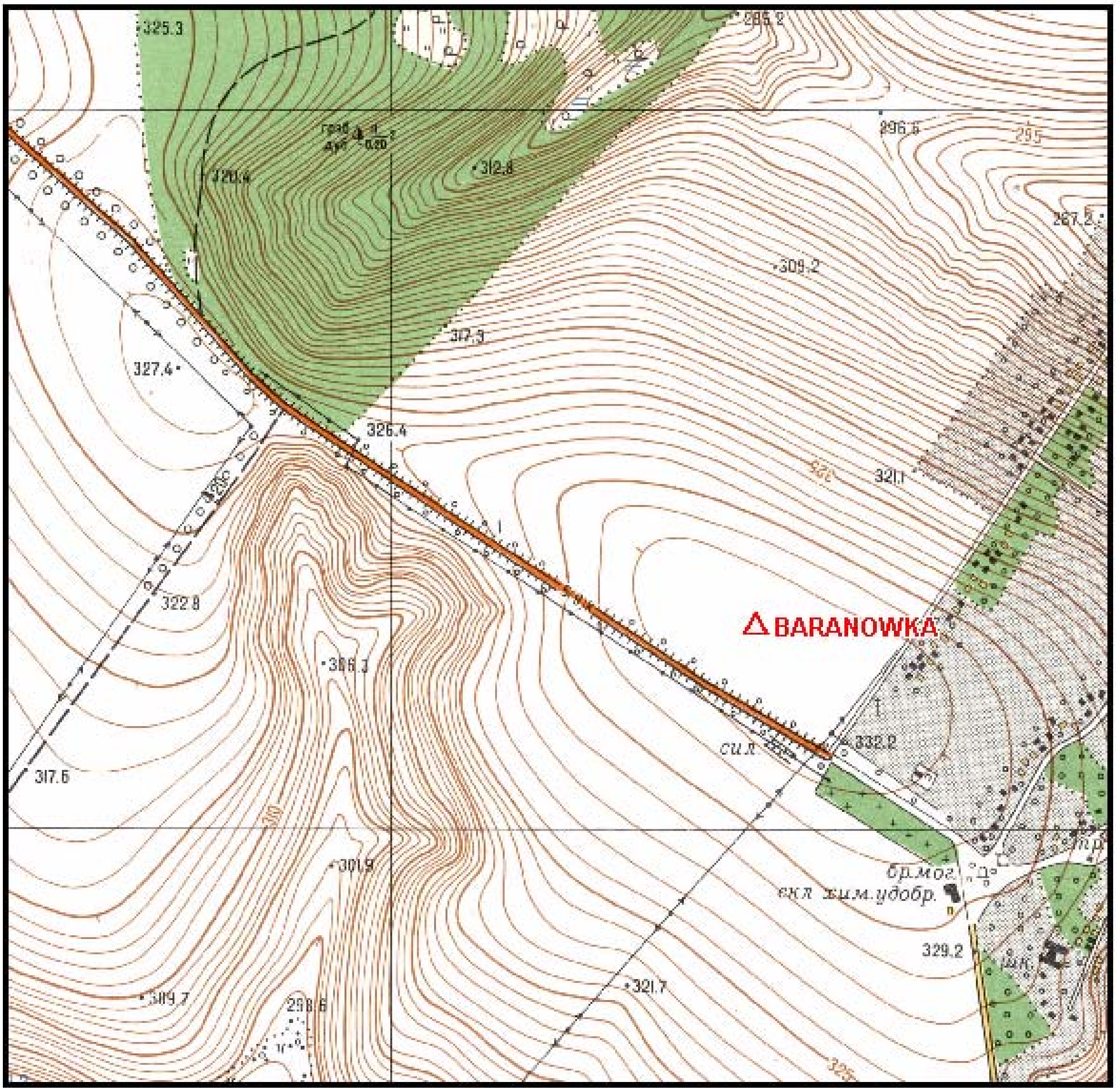


M 1:1000

Map 75.

FELSCHTIN (32). Location Map, :1.000.
The core zone 5*5 sq. m and the buffer zone 10*10 sq. m are shown on the map.

Location of BARANOWKA site

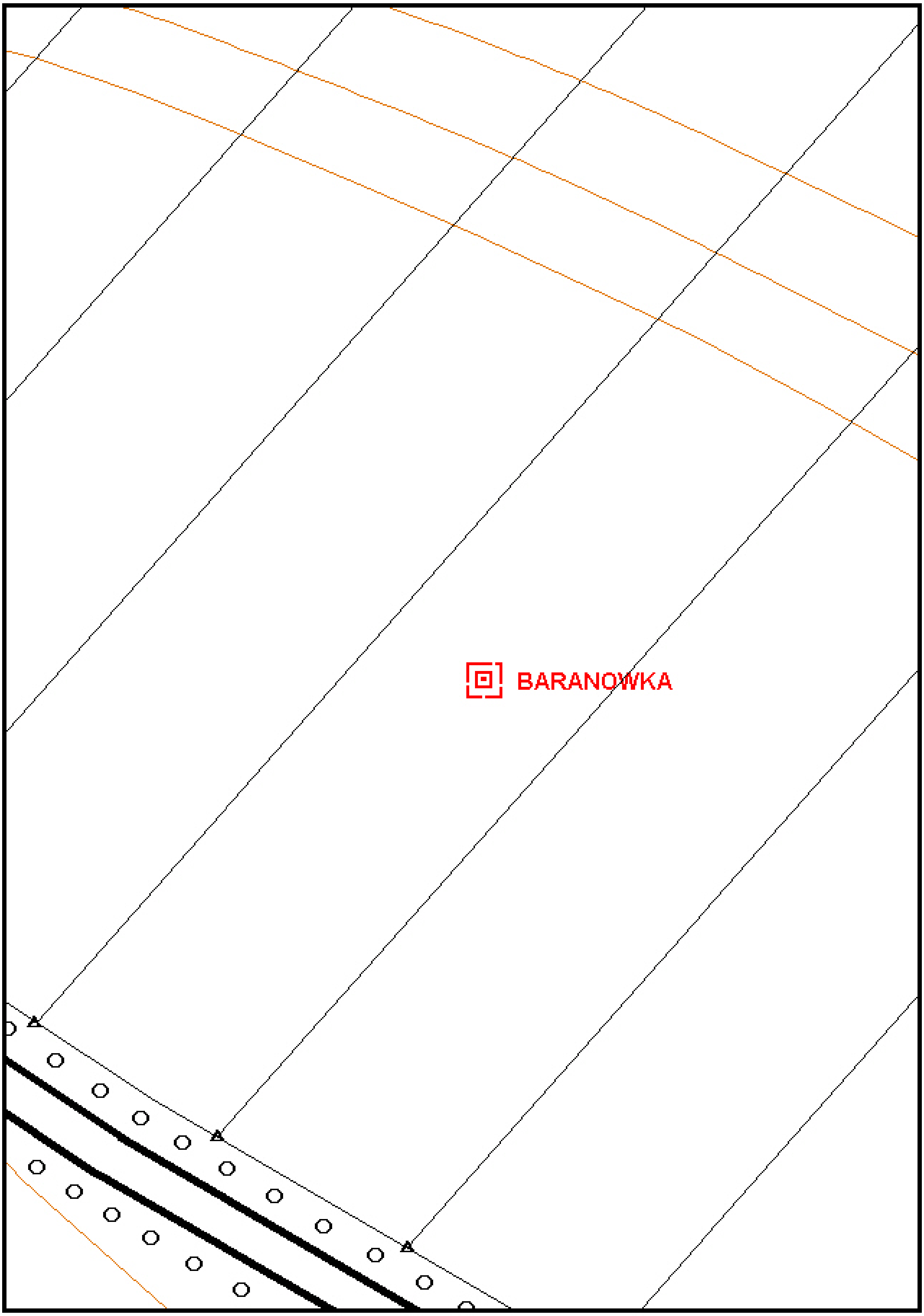


M 1:10000

Map 76.

BARANOWKA (33). Location Map, :10.000.

Location of BARANOWKA site



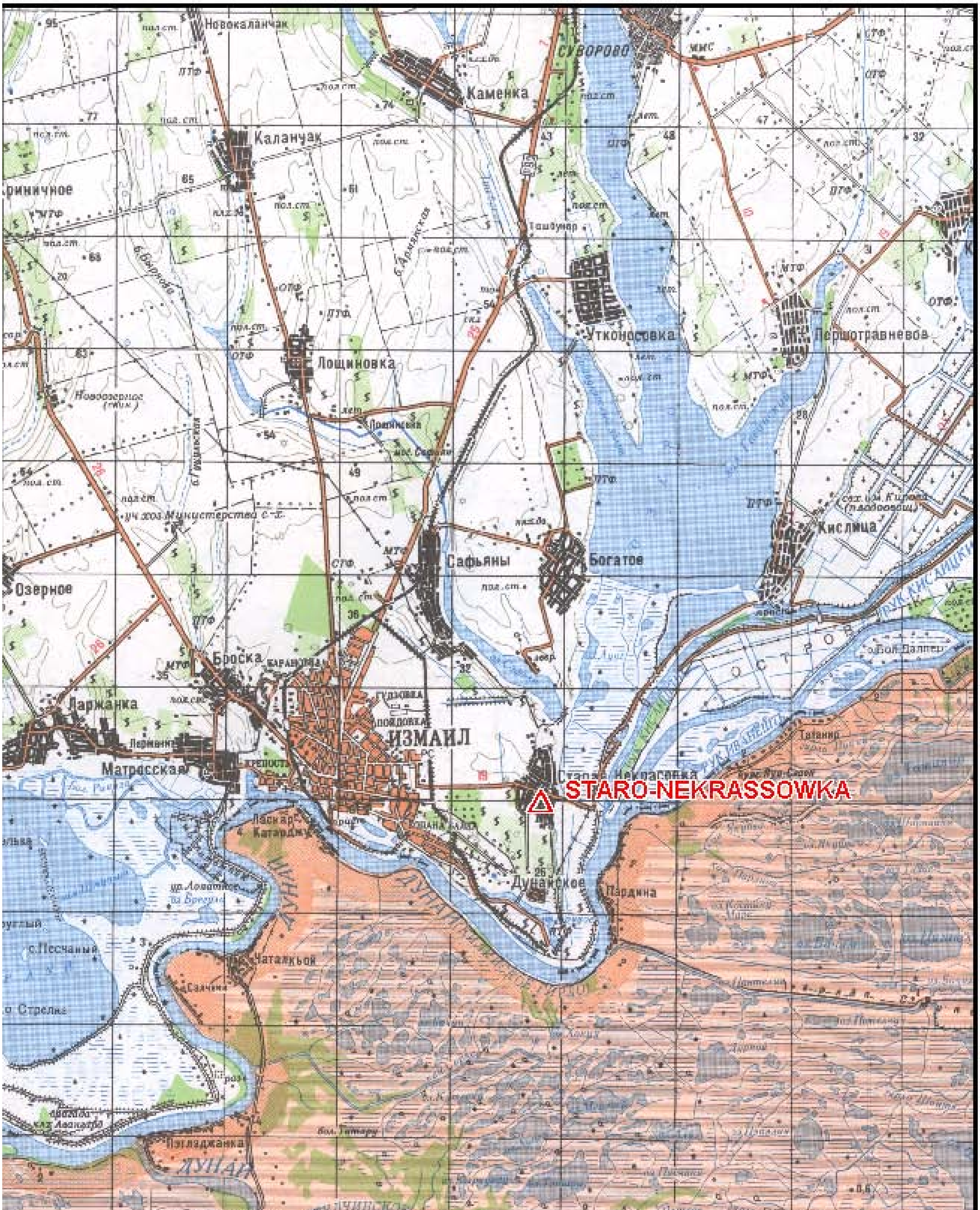
M 1:1000

Map 77.

BARANOWKA (33). Location Map, :1.000.

The core zone 3,2*3,2 sq. m and the buffer zone 6,3*6,3 sq. m are shown on the map.

Location of STARO-NEKRASSOWKA site



M 1:200000

Map 78.

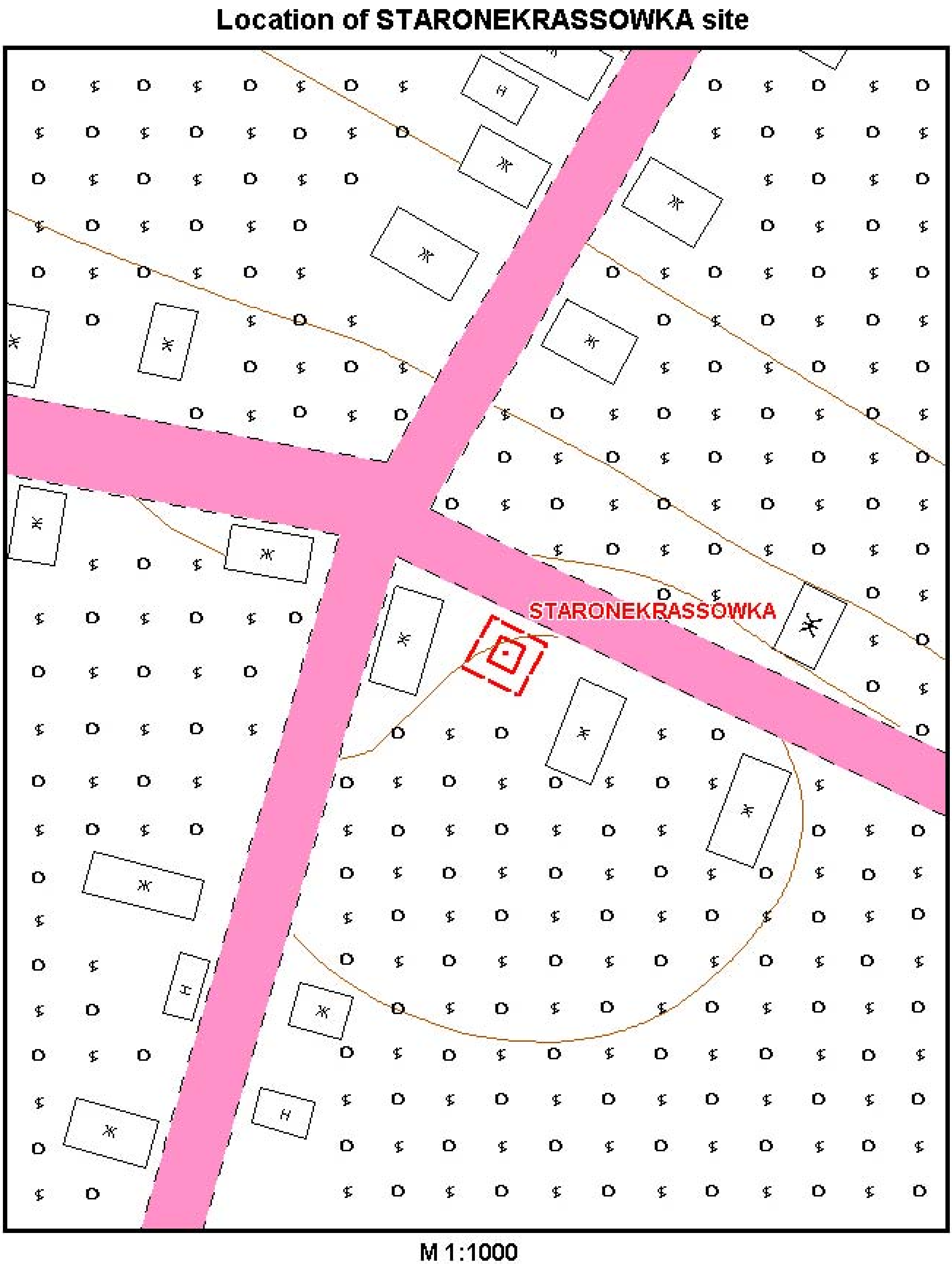
STARO-NEKRASSOWKA (34). Topographic Map, 1:200.000, Odessa region. Kyiv Military-Cartographic Factory, 2000.

Location of STARONEKRASSOWKA site

M 1:10000

Map 79.

STARO-NEKRASSOWKA (34). Location Map, 1:10.000.



Map 80.

STARO-NEKRASSOWKA (34). Location Map, 1:1.000.
The core zone 5*5 sq. m and the buffer zone 11,0*10,9 sq. m are shown on the map.

Appendix III

PHOTOGRAPHS

of

THE STRUVE GEODETIC ARC

PHOTOGRAPHS

APPENDIX

III

to

Nomination of the

STRUVE GEODETIC ARC

for inscription on the

WORLD HERITAGE LIST

January 2004

List of Photographs and Slides

Photographs

1. The monument of the arc at the northern terminal **FUGLENAES (1).** Hammerfest, Norway.
2. The inscriptions on the monument of the Arc, **FUGLENAES (1).** Hammerfest, Norway.
3. The monument on the site **FUGLENAES (1**). Hammerfest, Norway.
4. The Globe on the monument at the site **FUGLENAES (1).** Hammerfest, Norway.
5. The site **LOHDIZHJOKKI (3)** on the summit of Luvdiidhcokka. Kautokeino, Norway.
6. The site **BÄLJATZ-VAARA (4)** on the summit of Baelljasvarri. Kautokeino, Norway.
7. **PAJTASVAARA (5)** on the summit of Tynnyrilaki, Kiruna, Sweden.. (2003)
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12. **PULLINKI (7**). The summit of Pullinki where arc measurements were made. Sweden. (2001).
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14. **AVASAKSA (10**). The summit of Aavasaksa Mountain and the lookout tower. Ylitornio, Finland. (2002).
15. **AVASAKSA (10).** Engravings on the bedrock made by tourists at Aavasaksa, Ylitornio, Finland. (2002).
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17. **TORNEA (11).** The church of Alatornio. Tornio, Finland. (2002).
18. **TORNEA (11).** A view from the tower of Alatornio church to the north. Tornio, Finland. (2003).
19. **TORNEA (11).** A detail from a roof rafter in the tower of Alatornio church. Tornio, Finland. (2003).
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25. At the arc site **SVARTVIRA (14**), Pyhtää, Finland. (2002).
26. The arc site **SVARTVIRA (14).** The centre point right to the aiming circle. Pyhtää, Finland. (2002).
27. A view of the arc site **MÄKI-PÄÄLYS (15)** from SSE. Gogland, Russia. (2003).
28. A view of the arc site **MÄKI-PÄÄLYS (15**) from SW. Gogland, Russia. (2003).
29. A view of the arc site **HOGLAND, Z (16)** from east.. Gogland, Russia. (2003).
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38. **DORPAT (19).** The Tartu Observatory. Tartu, Estonia. (2002).

39. The target on the Struve Geodetic Arc station **DORPAT (19**. Tartu, Estonia. (2002).

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46. The arc station **KARISCHKI (22).** Panemunėlis, Lithuania (2003).

47. The hill of the arc station **MESCHKANZI (23).** Nemencinė, Lithuania (2003).

48. Remeasuring of the arc station **MESCHKANZI (23).** Nemenčinė, Lithuania (2003).

49. The arc station **BERESNÄKI (24).** Nemėžis, Lithuania (2003).

50. Excavation made under retrieval of the arc station **BERESNÄKI (24).** Nemėžis, Lithuania (2003).

51. **TUPISCHKI (25).** The centre marked with vertically walled stone brick. Oshmyany, Belarus. (2003).

52. **LOPATI (26).** The remaining hole of the centre pole.. Zelva, Belarus. (2003).

53. The centre of the arc site **OSSOWNITZA (27).** Ivanovo, Belarus. (2003).

54. The centre point of the arc site **TCHEKUTSK (28).** Ivanovo, Belarus. (2003).

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57. The arc site **KATERINOWKA (31).** Antonivka, Ukraine. (2003)

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59. The centre mark of the arc site **FELSCHTIN (32).** Hvardiiske, Ukraine (2003).

60. The arc site **FELSCHTIN (32).** Hvardiiske, Ukraine. (2003).

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65. The memorial plaque on the monument of **STARO-NEKRASSOWKA (34).** Nekrasivka, Ukraine.

66. **STARO-NEKRASSOWKA (34).** The monument at the S terminal of the arc. Nekrasivka, Ukraine. (2003).

Slides

The following photos are also copied on slide film and annexed to the Nomination:

2	**3**	**4**	**6**	**17**	**19**	**26**	**28**	**32**	**38**	**40**	**46**	**54**	**60**	**62**	**65**	**66**

Authorizations

Authorizations given by the ten State Parties are attached in this Appendix III. The uniform list of photographs and slides for which the authorization is given is the List of Photographs and Slides above.

Photograph 1.

The monument of the arc at the northern terminal FUGLENAES (1). Hammerfest, Norway.

Photograph 2.

The inscriptions on the monument of the Arc, FUGLENAES (1). Hammerfest, Norway.

Photograph 3.

The monument on the site FUGLENAES (1). Hammerfest, Norway.

Photograph 4.

The Globe on the monument at the site FUGLENAES (1). Hammerfest, Norway.

Photograph 5.

The site LOHDIZHJOKKI (3) on the summit of Luvdiidhcokka. Kautokeino, Norway.

Photograph 6.

The site BÄLJATZ-VAARA (4) on the summit of Baelljasvarri. Kautokeino, Norway.

Photograph 7.
PAJTASVAARA (5) on the summit of Tynnyrilaki, Kiruna, Sweden. Signal pole and stones on the spot where the Struve arc measurement was made. (2003)

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PULLINKI (7). The mountain Pullinki from northeast. Övertorneå, Sweden. (2003).

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PERRA-VAARA (8). The cross-mark from Struve arc measurement on Perävaara. Haparanda, Swden. (2002).

Photograph 14.
AVASAKSA (10). The summit of Aavasaksa Mountain and the tower. Ylitornio, Finland. (2002).

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AVASAKSA (10). Engravings on the bedrock made by tourists on the summit of Aavasaksa, Ylitornio, Finland. (2002).

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AVASAKSA (10). An information map of Aavasaksa. Yli-tornio, Finland. (2002).

Photograph 17.

TORNEA (11). The church of Alatornio. Tornio, Finland. (2002).

Photograph 18.

TORNEA (11). A view from the tower of Alatornio church to the north. Tornio, Finland. (2003).

Photograph 19.

TORNEA (11). A detail from a roof rafter in the tower of Alatornio church. Tornio, Finland. (2003).

Photograph 20.

TORNEA (11). The tower of the church of Alatornio. Tornio, Finland. (2002).

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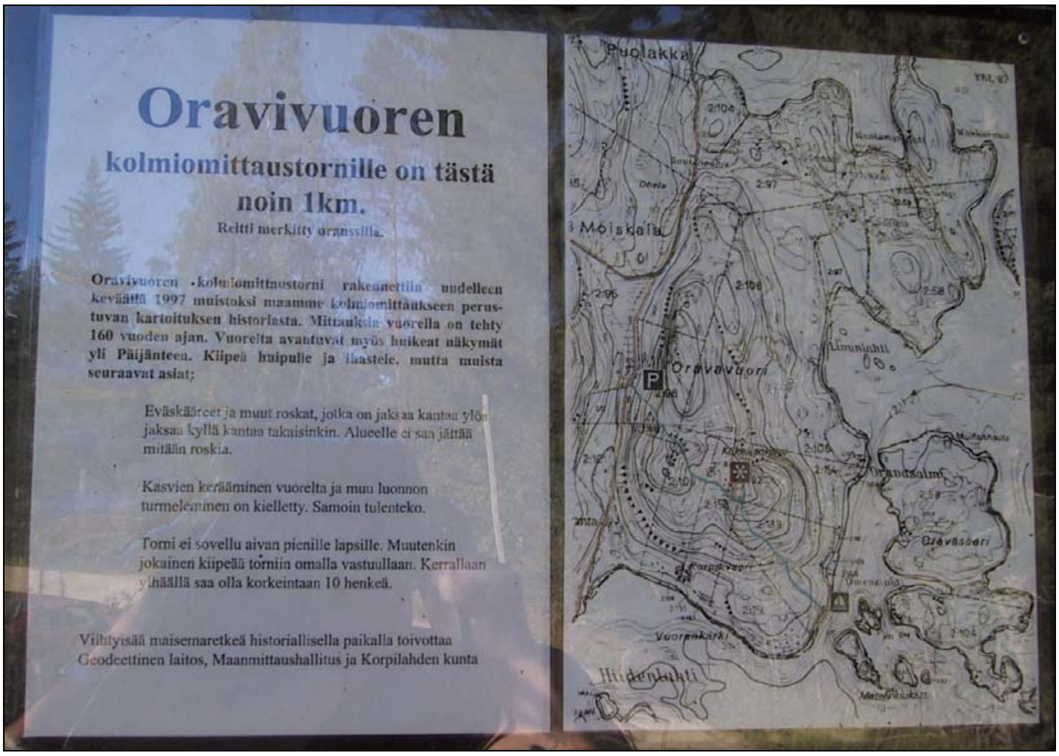
TORNEA (11). A view from the tower of Alatornio church to the south. Tornio, Finland. (2003).

Photograph 22.

TORNEA (11). The interior from Alatornio churc. Tornio, Finland. (2002).



Photograph 23.

The information board near the arc site PUOLAKKA (12). Korpilahti, Finland. (2002).

Photograph 24.

SVARTVIRA (14). The remnants of the ruined triangulation tower on the Island Mustaviiri. At the back Mr. Jarmo Ratia and Mr. Matti Haanperä of National Land Survey of Finland. Pyhtää, Finland. (2002).

Photograph 25.

At the arc site SVARTVIRA (14), Mr. Pekka Tätilä and Mr. Jarmo Ratia of National Land Survey of Finland. Pyhtää , Finland. (2002).

Photograph 26.

The arc site SVARTVIRA (14). The centre point right to the aiming circle. Pyhtää, Finland. (2002).

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A view of the arc site MÄKI-PÄÄLYS (15) from SSE when approaching along the existing path. Gogland, Russia. (2003).

Photograph 28.

A view of the arc site MÄKI-PÄÄLYS (15) from SW. Gogland, Russia. (2003).

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A view of the arc site HOGLAND, Z (16) from north. Gogland, Russia. (2003).

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WOIBIFER (17). The basement and the centre block of the NW terminal of Simuna baseline.
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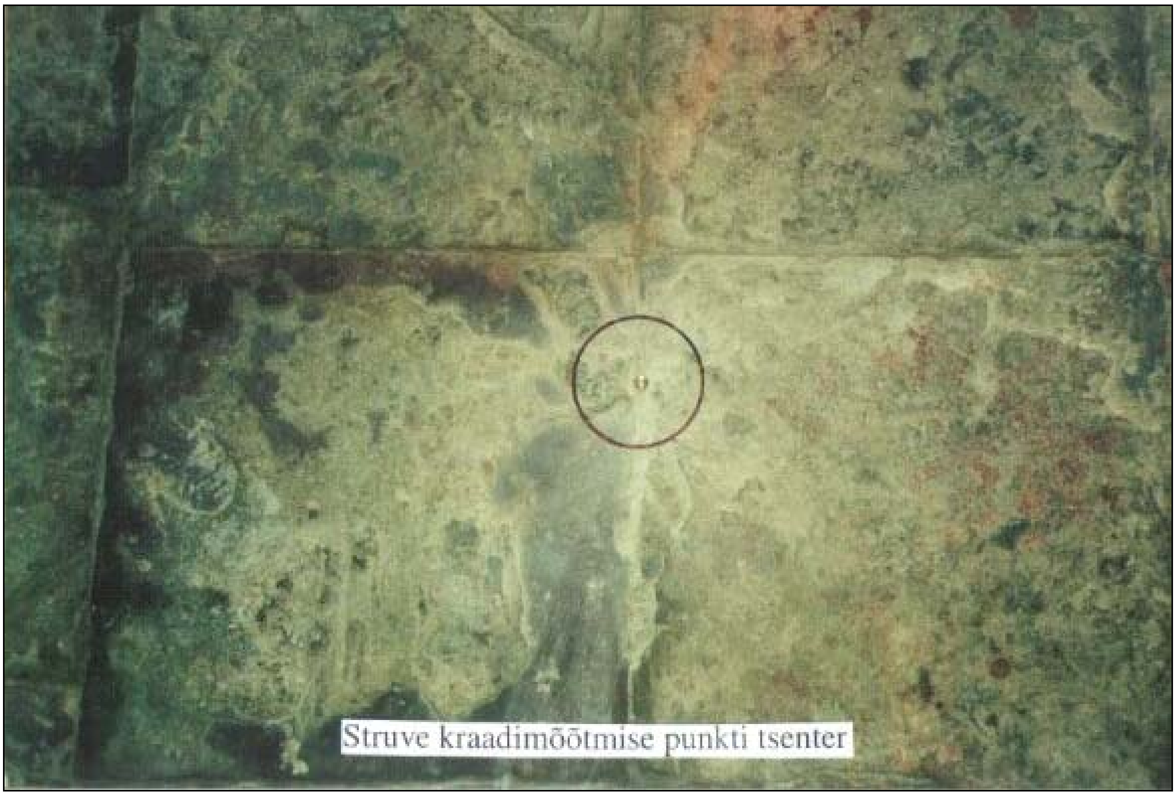

Photograph 37.

The centre point of the Struve Geodetic Arc station DORPAT (19) in the entrance hall of the Observatory of Tartu University. Tartu, Estonia. (2002).

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DORPAT (19). The Tartu Observatory. Tartu, Estonia. (2002).

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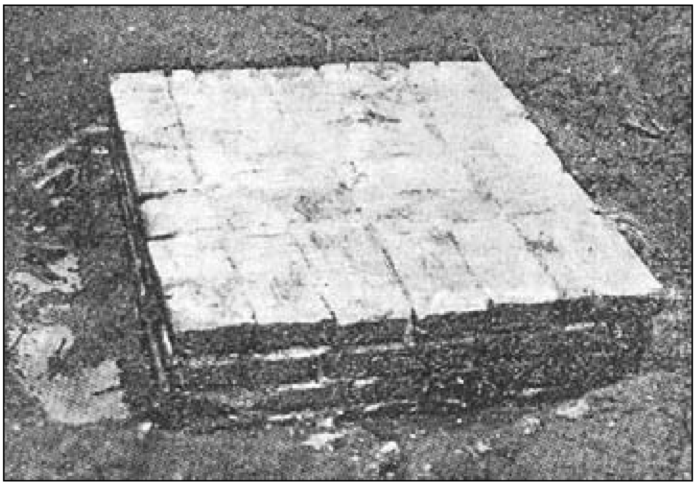
The target on the Struve Geodetic Arc station DORPAT (19) in the entrance hall of the Observatory during remeasurement. Tartu, Estonia. (2002).

Photograph 40.

The centre block of the arc site SESTU-KALNS (20). Sausnēja, Latvia. (2002).



Photograph 41.

JACOBSTADT (21). The basement of the point before the year 1931.

Photograph 42.

JACOBSTADT (21). The centre block after renovation made in 1931.

Photograph 43.

The centre mark of the arc site JACOBSTADT (21). Jēkabpils, Latvia (2002).

Photograph 44.

The sign commemorating the station JACOBSTADT (21). Behind the board Mr. Dzintras Ikass. of the State Land Service of Latvia. Jēkabpils, Latvia (2002).

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The hill of the arc station KARISCHKI (22). Panemunėlis, Lithuania (2003).

Photograph 46.

The arc station KARISCHKI (22). Panemunėlis, Lithuania (2003).

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The hill of the arc station MESCHKANZI (23). Nemencinė, Lithuania (2003).

Photograph 48.

Remeasuring of the arc station MESCHKANZI (23). Nemenčinė, Lithuania (2003).

Photograph 49.

The arc station BERESNÄKI (24). Nemėžis, Lithuania (2003).

Photograph 50.
Excavation made under retrieval of the arc station BERESNÄKI (24). Nemėžis, Lithuania (2003).

Photograph 51.

TUPISCHKI (25). The centre of the site marked with vertically walled stone brick. Oshmyany, Belarus. (2003).

Photograph 52.

LOPATI (26). The remaining hole of the centre pole. The centre of the arc point was fixed there by wooden pole walled and limed with stone bricks. Zelva, Belarus. (2003).

Photograph 53.

The centre of the arc site OSSOWNITZA (27). Ivanovo, Belarus. (2003).

Photograph 54.

The centre point of the arc site TCHEKUTSK (28). Ivanovo, Belarus. (2003).

Photograph 55.

The centre point of arc site LESKOWITSCHI (29). Ivanovo, Belarus. (2003).

Photograph 56.

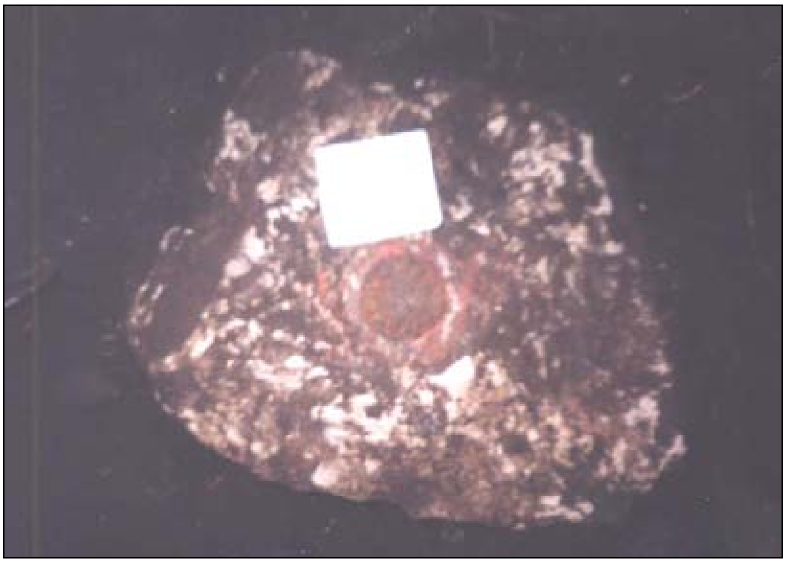
The centre block of the arc site RUDY (30). Rudi, Moldova. (2003).

Photograph 57.

The arc site KATERINOWKA (31). Antonivka, Ukraine. (2003)

Photograph 58.

The memorial plaque at the arc site KATERINOWKA (31). Antonivka, Ukraine. (2003).



Photograph 59.

The centre mark of the arc site FELSCHTIN (32). Hvardiiske, Ukraine (2003).

Photograph 60.

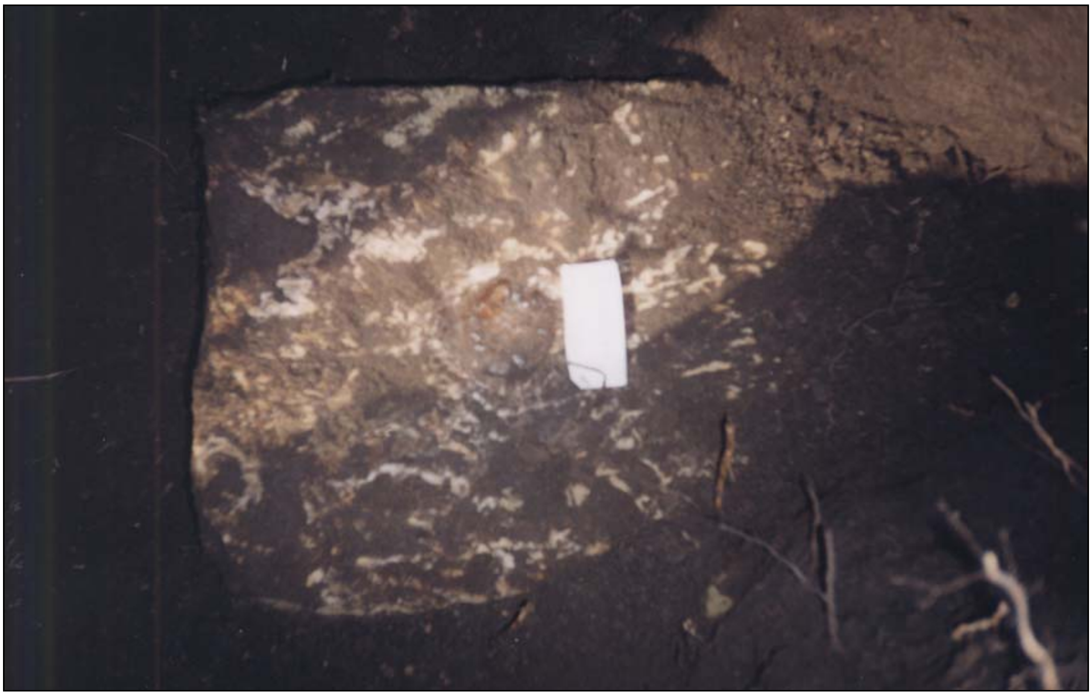
The arc site FELSCHTIN (32). Hvardiiske, Ukraine. (2003).

Photograph 61.

The ridge of the arc site FELSCHTIN (32). Hvardiiske, Ukraine. (2003).

Photograph 62.

The memorial plaque at the arc site FELSCHTIN (32). Hvardiiske, Ukraine. (2003).



Photograph 63.

The centre mark of the arc site BARANOWKA (33). Baranivka, Ukraine (2003).

Photograph 64.

The memorial plaque at the arc site BARANOWKA (33). Baranivka, Ukraine. (2003).

Photograph 65.

The memorial plaque with the Latin text on the monument of STARO-NEKRASSOWKA (34). Nekrasivka, Ukraine.

Photograph 66.

STARO-NEKRASSOWKA (34). The monument at the southern terminal of the arc. Nekrasivka, Ukraine. (2003).

AUTHORIZATION

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   e) exhibitions, etc.

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7. I hereby undertake to indemnify Unesco, and to hold it harmless of any responsibility, for any damages resulting from any violation of the certification mentioned under paragraph 6 of the present authorization.

8. Any differences or disputes which may arise from the exercise of the rights granted to Unesco will be settled in a friendly way. Reference to courts or arbitration is excluded.

Belarus, Minsk 10 Jan 2004

GEORQY KYZNETSOV
Chairman
Committee for Land Resources, Geodesy and Cartography Under the Council of Ministers

AUTHORIZATION

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TALLINN, 7th January 2004

Deputy Director General of Estonian Land Board

Place	Date	Signature, title or function of the person duly authorized

AUTHORIZATION

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Helsinki, January 13, 2004

Jarmo Ratia
Director General
National Land Survey of Finland

AUTHORIZATION

1. I, the Director General of the State Land Service of Republic of Latvia Guntis Grūbe, the undersigned, hereby grant free of charge to Unesco the non-exclusive right for the legal term of copyright to reproduce and use in accordance with the terms of paragraph 2 of the present authorization throughout the world the photograph(s) and/or slide(s) described in paragraph 4.

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Riga 12.01.2004. G.Grūbe, Director General

Place Date Signature, title or function of the person duly authorized

LATVIJAS REPUBLIKAS VALSTS ZEMES DIENESTS

AUTHORIZATION

1. I, Petras Petroškevičius ....
the undersigned, hereby grant free of charge to Unesco the non-exclusive right for the legal term of copyright to reproduce and use in accordance with the terms of paragraph 2 of the present authorization throughout the world the photograph(s) and/or slide(s) described in paragraph 4.

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Vilnius	20030901	
Place	Date	Signature, title or function of the person duly authorized

Director of Geodetic Institute

Geodezijos institutas

AUTHORIZATION

1. I, Nicolae Şveţ, the undersigned, hereby grant free of charge to UNESCO the non-exclusive right for the legal term of copyright to reproduce and use in accordance with the terms of paragraph 2 of the present authorization throughout the world the photograph(s) described in paragraph 4.

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   e) exhibitions, etc.

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4. The list of photograph(s) for which the authorization is given is attached.
   - Section of topographic map at scale 1:50 000;
   - Section of topographic map at scale 1:25 000;
   - Section of topographic map at scale 1:10 000;
   - Aerial images for settlement Rudi;
   - Ground photographs of the point RUDY.

5. All photographs will be duly credited. The photographer's moral rights will be respected.

6. I hereby declare and certify that I am duly authorized to grant the rights mentioned in paragraph 1 of the present authorization.

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Nicolae Şveţ,
General Director of the
State Agency for Land
Relations and Cadastre
Republic of Moldova

Chisinau, 30th September 2003

AUTHORIZATION

1. I, Bjorn Geirr HARSSON ....
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Photo: Bjorn Geirr HARSSON

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Hønefoss	1 Aug. 2003	Bjørn Geirr Harsson
Place	Date	Signature, title or function of the person duly authorized

Chief Engineer
Geodetic Institute
Norwegian Mapping Authority

AUTHORIZATION

YUSKEVICH Alexander

the undersigned, hereby grant free of charge to Unesco the non-exclusive right for the legal term of copyright to reproduce and use in accordance with the terms of paragraph 2 of the present authorization throughout the world the photograph(s) and/or slide(s) described in paragraph 4.

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St-Petersburg, Russia, November 13, 2003

Place date

Signature, title or function of the person duly authorized

Official in responsibility for the Russian part of the nomination:

Alexander Yuskevich
Director General Federal State
Unitary Enterprise
"Aerogeodeziya"

Dnr: L2004/195

AUTHORIZATION

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Gävle	26/1 2004	[signature]
Place	Date	Signature, title or function of the person duly authorized

Lantmäteriet
S-80182 GÄVLE
LAND AND GEOGRAPHICAL
INFORMATION SERVICE

MINISTRY OF ENVIRONMENT AND NATURAL RESOURSES OF UKRAINE
STATE SERVICE OF GEODESY, CARTOGRAPHY AND CADASTRE OF UKRAINE

RIGC

RESEARCH INSTITUTE GEODESY & CARTOGRAPHY

"22" 07 2003 N 284
On ________ of ________

Pekka Tatila
Chief Engineer
National Land Survey of Finland
PO Box 84, 00521, Helsinki, Finland

AUTHORIZATION

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Deputy director RIGC Кучер *Oleg Kucher*

Україна * Науково-дослідний інститут геодезії і картографії * м. Київ * НДІГК Ідентифікаційний код 24102001

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NATIONAL LAND SURVEY OF FINLAND

Draft 07-04-04/pt

MANAGEMENT MECHANISM

for

STRUVE GEODETIC ARC

Background

The Struve Geodetic Arc is a chain of triangulation survey stretching more or less down the 25º E line of longitude from Hammerfest in North Norway on the Arctic Ocean over 2820 kms south to Ismail on the Black Sea in Ukraine. The Arc was set up and measured from 1816 to 1855. The goal was to determine the dimensions of the Earth, its shape and size. In today's geography it passes trough ten countries, i.e. Norway, Sweden, Finland, Russia Federation, Estonia, Latvia, Lithuania, Belarus, Moldova and Ukraine.

The ten countries of the Arc have together submitted the "Nomination of Struve Geodetic Arc for Inscription on the World Heritage List". The Struve Arc would be an international transboundary serial nomination with the selection of 34 measuring properties. According the common procedures and guidelines based on the World Heritage Convention each country is responsible to take care of preservation and other management of the properties within its territory.

In the section 4 in the Nomination Document has been described the status and procedures of the national legislation, preservation, management etc. While all these kind activities are solely ruled and guided by each country itself there is a need for a common Management Mechanism agreed and implemented by all the ten countries jointly. This document *"Management Mechanism for Struve Arc"* will form basic guidelines in this coordination.

Objectives

The main objective of participating States Parties is, by stages through co-operation in the Coordinating Committee, to create rules and good practice to preserve and sustain the World Heritage "Struve Geodetic Arc". The aim is based on Arc's proper protection, conservation, management, presentation and understanding. The selected 34 properties will present the whole chain of triangulation survey called the Struve Arc. Besides these selected points also other survived points will be preserved according the normal national practice of country concerned.

The basic responsibility for all kind of management and actions of individual properties must rest with the individual States Parties and be carried out by each of them in accordance of their legislative and management systems. The role of the Coordinating Committee is to produce common guidelines for management, to monitor the progress of preservation of the sites.

Coordinating Committee

The ten countries of the Struve Arc will form a Coordinating Committee. Each country will nominate its representative(s) to the Committee. Based on the practice gained within the nomination process the main actors will be the National Land Boards of the ten countries as described in the Section 4 “Management” in the Nomination Document. Almost all the sites are also today used for surveying purpose and National Land Board are dealing in any case with sites. They also have skill people and other means for management purposes. The National Boards of Antiquities of the ten countries will provide the substance knowledge of preservation. They can nominate their representatives to the Coordinating Body directly or they can consult with the representative of their National Land Board in these matters.

Each country can nominate in maximum [2] persons to the Coordinating Committee. One of them is the national Contact Person and all official contacts from and to Coordinating Committee will be made trough him or her. One Contact person will be selected to the chairman of the Committee.

Activities of the Coordinating Committee

The main activities of the coordinating committee will be carried out under following common topics

- to follow up the status of preservation and achievements of promotion in various countries of the Arc
- to collect the yearly reports of the ten countries, make decisions and actions based on them and make yearly report to World Heritage Centre
- to give recommendations and instructions to the management organisation of the ten countries in order to uniform the practice and guidelines to manage the Arc
- to uniform the practice to mark out the sites and to develop their use for educational and tourist attractions
- to promote the national preservation of other than originally selected 34 sites of the Arc and to create principles how to adopt new points to “primary” category
- to contribute in the research work and in getting records of the Struve Arc available for wider community
- to plan and guide possible re-measurements of certain part of the Arc points with satellite techniques
- to take care all such kind of proposals and activities which will as a whole contribute to create and to sustain the living World Heritage “The Struve Geodetic Arc”.

Struve Geodetic Arc

No 1187

1. BASIC DATA

State Parties:	Belarus, Estonia, Finland, Latvia, Lithuania, Norway, Republic of Moldova, Russian Federation, Sweden, Ukraine
Name of property:	Struve Geodetic Arc
Location:	Different parts of the nominating States
Date received:	28 January 2004

Category of property:

In terms of the categories of cultural property set out in Article 1 of the 1972 World Heritage Convention, this is a *site.*

Brief description:

The Struve Arc is a chain of survey triangulations, stretching from Hammerfest in Norway to the Black Sea, through 10 countries and over 2820 km. These are points of a survey, carried out between 1816 and 1855, by the astronomer Friedrich Georg Wilhelm Struve. The original arc consisted of 258 main triangles with 265 main station points. The survey helped in determining the shape of earth and its size and played an important role in the development of accurate topographic mapping. The nomination includes 34 of the original station points, with different marking – from a drilled hole in rock, through iron cross, cairns, or built obelisks.

2. THE PROPERTY

Description

Since around 500 BC it had been known that the earth was not flat, but of some spherical shape. In the 3rd century BC the surveying technique and theory, for determining the size of the earth, has been developed by Eratosthenes. This theory remained in use until the era of satellite geodesy. Eratosthenes' theory, using length measurement and angles determined by star observations made it possible to determine the size of earth, while the measurements themselves were still not accurate, mainly due to methods and equipment.

In the 17th century better measuring equipment was developed, together with a new method, using triangulations. According to this method, a much shorter line had to be measured accurately, while the long distances were covered by a chain of triangles. These triangles, spanning several hundreds kilometres, having each of their sides (**base lines**) as long as 100 km and each triangle in the chain having at one common base line with at least one other triangle and two common corners or **station points** with another triangle.

The triangulation method helped establishing in the 1730s-40s the true shape of earth, through long arcs in Peru and Lapland. There was still the unsolved problem of the size of the world, getting now even more complicated, knowing that the world is not a perfect sphere. The different early arcs in France, Peru, Lapland, Italy, S. Africa and Austria had different shortcomings which did not allow for an accurate solution of this issue.

The defeat of Napoleon, followed by the Vienna conference and the decision in 1815 of the establishment of agreed international boundaries in Europe required accurate mapping. At the same time, accurate mapping became a priority for the new European rulers who did not trust a long lasting peace and needed those maps for military purposes. These needs were strongly felt in Russia, where Tsar Alexander the 1st provided the astronomer Wilhelm Struve with all the resources for a project he suggested of a new long geodetic arc. This can be seen as the first step for the development of modern geodetic framework and topographic mapping.

At this time a very long arc has been measured in India by Lambton and Everest, completed in 1840. Another, shorter arc has been measured in Lithuania, by Carl Tenner. Struve was aware of these arcs and at the opportunities presented by their results (two long arcs are needed to establish the most accurate shape and size of the world). Struve was working at the Dorpat (Tartu) university in nowadays Estonia, and decided that the arc he is going to establish will follow a line of longitude (meridian) passing through the observatory of the university. The new long arc, called later "The Struve Arc" was finally established by connecting earlier, shorter arcs, with a southern one measured by Tenner, and their extension to the north and south. The arc covered thus a line connecting Fuglenaes near Hammerfest in the far north, along 2800 kms, with Staro-Nekrasowka, near Ismail, on the Black Sea shores. It stretches today through ten different countries.

The subject of this nomination are 34 of the original **station points** established by Struve and his colleagues, between 1816 and 1851, in order to establish the Struve Arc (see the attached list).

There are 4 points in Norway, 4 in Sweden, 6 in Finland, 1 in Russia, 3 in Estonia, 2 in Latvia, 3 in Lithuania, 5 in Belarus, 1 in Moldova and 4 in Ukraine.

The full description of each one of the 34 nominated points is in the nomination file. In general, these are different markings which could be described as:

- Small hole drilled in rock surface. Sometimes filled with lead.
- Cross shaped engraved mark on rock surface.
- Solid stone or brick with a marker set in it.
- Structure of rocks (cairn), with a central stone or brick, marked by a drilled hole.
- Single brick.
- Specially constructed "monument" to commemorate the point and the arc.

Management regime

Each of the nominating countries has their own regime to manage the heritage. At the same time the ten countries are setting up a joint "management mechanism", in the form of a coordinating committee, to coordinate the management of the nominated sites.

Many of the nominated "sites" are points in rock or of another shape, with very small area around them, as part of the nomination. Most of them are still part of the national geodetic system and therefore still in potential use and practical importance. Therefore they are managed by national geodetic services and controlled by national cultural heritage institutions.

The existing management and legal protection were two of the criteria used by the state parties to choose the 34 points out of many more in the Struve Arc.

Legal provision:

All the suggested points are legally protected, and in most cases by two laws – the one protecting geodetic points and the other for the protection of cultural heritage.

Resources:

Most of financial resources are provided by the geodetic services, as a regular activity of maintaining their active geodetic points. They are also responsible for the regular maintenance of the sites. Few of the nominating states indicated that additional funding will be required if the sites are inscribed on the World Heritage list. These funds will be required for setting the proper plaques and for the improvement of presentation.

Justification by the State Parties (summary)

Determining the size and shape of the world has been one of the most important problems of natural philosophy since at least the 4th century BC. The development, in the 17th century, of a measuring system called "triangulation", improved the ability to determine the size and shape of the world. By this system long chains of triangles, creating "arcs", were measured stretching along hundreds and thousands of kilometres. "Struve Geodetic Arc" is one of them.

No accurate mapping is possible without a framework of triangulation stations. No navigation, planning or any cartography, is possible without such mapping. The arcs helped in developing this system and its accuracy.

Struve's arc is outstanding in its length (over 2820 km) and accuracy. Only an arc completed in 1954 exceeded it for length. Its accuracy equals to 4 mm in a km. It assisted in developing new and more accurate measuring equipment, and indirectly in the "promotion" of the standard metric system. It was the first meridian measurement crossing borders of several countries – now ten. It was the base for mapping the countries it went through as well as of Central Eastern Europe.

Suggested Criteria:

Criterion ii: The site exhibits an important interchange of human values of collaboration amongst scientists from different countries. It exhibits an important step in the development of the sciences of the earth and the use of the state of the art technologies.

Criterion iii: The arc bears an exceptional testimony of measuring the earth over a time of three centuries, using trigonometric and astronomical observations along lines of longitude.

Criterion iv: The points of the arc are an outstanding example of an extraordinary development in science and knowledge of the world.

Criterion vi: The points of the arc are associated with Sir Isaac Newton's theory that the world was not an exact sphere, but rather an oblate spheroid.

3. ICOMOS EVALUATION

Actions by ICOMOS

An ICOMOS evaluation mission visited the sites in August 2004 and an ICOMOS representative attended a conference on the “Future of the Struve Geodetic Arc” held in September 2004.

ICOMOS has also received scientific desk evaluations and consulted its International Scientific Committee on CIPA – Heritage Documentation.

Conservation

The state of conservation of the different points being nominated is good. Many of them are still part of their national geodetic grid, and permanently maintained.

Conservation history:

The historic-cultural importance of some of the points was recognized long ago and many of them came under the protection of the cultural heritage legislation of the relevant countries. As recognized monuments, all rules were applied, including those of conservation. Most points lost their original plaques or lead in the holes. Some were re- installed, but at the exact original place.

Management:

The sites are properly managed.

Risk analysis:

The only potential risk could be the result of more visitors, following a World Heritage inscription. Such risk is one of the considerations of the new coordinating body created by the nominating countries.

Authenticity and integrity

This point is almost not applicable because of the special characteristics and value of the nominated property. All points are in their original location, some are in remote areas which have not been changed since the creation of the arc.

Comparative evaluation

There were earlier arcs than the Struve and there are longer ones now. The Struve Arc though was the longest and most accurate when created and the longest for more than a century. It was the first for which special equipment was created and the first one crossing several countries

Outstanding universal value

General statement:

The Struve Arc has certainly Outstanding Universal Value, based on its contribution to the development of sciences, and collaboration amongst scientists, monarchs and nations.

ICOMOS believes that this nomination has an added value, being based on technological-scientific values and being submitted by ten state parties together.

An extension of this nomination, to include the arc connecting it with South Africa, should be considered in future.

Evaluation of criteria:

The nomination meets criteria ii, iv, vi.

Criterion iii does not apply.

4. ICOMOS RECOMMENDATIONS

Recommendation with respect to inscription

ICOMOS recommends that the World Heritage Committee adopt the following draft decision:

The World Heritage Committee,

1. Having examined Document WHC-05/29.COM/8B,

2. Inscribes the property on the World Heritage List on the basis of ***criteria ii, iv and vi***:

> ***Criterion ii***: The first accurate measuring of a long segment of a meridian, helping in the establishment of the exact size and shape of the world exhibits an important step in the development of earth sciences. It is also an extraordinary example for interchange of human values in the form of scientific collaboration among scientists from different countries. It is at the same time an example for collaboration between monarchs of different powers, for a scientific cause.
>
> ***Criterion iv***: The Struve Geodetic Arc is undoubtedly an outstanding example of technological ensemble – presenting the triangulation points of the measuring of the meridian, being the non movable and non tangible part of the measuring technology.
>
> ***Criterion vi***: The measuring of the arc and its results are directly associated with men wondering about his world, its shape and size. It is linked with Sir Isaac Newton's theory that the world is not an exact sphere.

ICOMOS, April 2005

Site No	**ORIGINAL NAME** **Present name**	**State Party**
1	**FUGLENAES** Fuglenes	Norway
2	**LILLE-REIPAS** Raipas	Norway
3	**LOHDIZHJOKKI** Luvdiidcohkka	Norway
4	**BÄLJATZ-VAARA** Baelljasvarri	Norway
5	**PAJTAS-VAARA** Tynnyrilaki	Sweden
6	**KERROJUPUKKA** Jupukka	Sweden
7	**PULLINKI** Pullinki	Sweden
8	**PERRA-VAARA** Perävaara	Sweden
9	**STUOR-OIVI** Stuorrahanoaivi	Finland
10	**AVASAKSA** Aavasaksa	Finland
11	**TORNEA** Alatornion kirkko	Finland
12	**PUOLAKKA** Oravivuori	Finland
13	**PORLOM II** Tornikallio	Finland
14	**SVARTVIRA** Mustaviiri	Finland
15	**MÄKI-PÄÄLYS** Mäkipällys	Russia
16	**HOGLAND, Z** Gogland, Tochka Z	Russia
17	**WOIBIFER** Võivere	Estonia
18	**KATKO** Simuna	Estonia
19	**DORPAT** Tartu Observatory	Estonia
20	**SESTU-KALNS** Ziestu	Latvia
21	**JACOBSTADT** Jekabpils	Latvia

22	**KARISCHKI** Gireišiai	Lithuania
23	**MESCHKANZI** Meškonys	Lithuania
24	**BERESNÄKI** Paliepiukai	Lithuania
25	**TUPISCHKI** Tupishki	Belarus
26	**LOPATI** Lopaty	Belarus
27	**OSSOWNITZA** Ossovnitsa	Belarus
28	**TCHEKUTSK** Chekutsk	Belarus
29	**LESKOWITSCHI** Leskovichi	Belarus
30	**RUDY** Rudi	Moldova
31	**KATERINOWKA** Katerinowka	Ukraine
32	**FELSCHTIN** Felschtin	Ukraine
33	**BARANOWKA** Baranowka	Ukraine
34	**STARO- NEKRASSOWKA** Stara Nekrasivka	Ukraine

Map showing the location of the nominated property

The Tartu Observatory - Tartu, Estonia – Dorpat (19)

The monument at the northern terminal of the arc - Fuglenaes (1), Norway

Arc géodésique de Struve

No 1187

1. IDENTIFICATION

États parties : Belarus, Estonie, Finlande, Lettonie, Lituanie, Norvège, République de Moldavie, Fédération de Russie, Suède, Ukraine

Bien proposé : Arc géodésique de Struve

Lieu : Différentes parties des États

Date de réception : 28 janvier 2004

Catégorie de bien :

En termes de catégories de biens culturels telles qu'elles sont définies à l'article premier de la Convention du patrimoine mondial de 1972, il s'agit d'un *site.*

Brève description :

L'arc de Struve est un réseau de triangulations qui s'étend de Hammerfest en Norvège jusqu'à la mer Noire et traverse 10 pays sur plus de 2820 km. L'arc est composé des points d'une triangulation réalisée entre 1816 et 1855 par l'astronome Friedrich Georg Wilhelm Struve. L'arc d'origine était constitué de 258 triangles principaux et de 265 points fixes principaux. La triangulation contribua à définir et mesurer la forme de la terre et joua un rôle important dans l'établissement de cartes topographiques précises. La proposition d'inscription comprend 34 des points fixes d'origine, avec différents marquages – trous percés dans la roche, croix en fer, cairns ou obélisques.

2. LE BIEN

Description

Vers 500 av. J.-C., il était déjà établi que la terre n'était pas plate mais sphérique. Au IIIe siècle av. J.-C., Eratosthènes conçut une théorie et une méthode topographique pour mesurer la taille de la terre. Cette théorie fut en usage jusqu'à l'ère du satellite géodésique : elle proposait de déterminer la taille de la terre en mesurant des longueurs et des angles par l'observation des étoiles. À l'époque, les mesures n'étaient pas exactes, essentiellement en raison des méthodes et des équipements utilisés.

Le XVIIe siècle disposa de meilleurs instruments de mesure et d'une nouvelle méthode utilisant la triangulation. Grâce à cette méthode, une ligne beaucoup plus courte devait être mesurée avec précision, tandis que les grandes distances étaient parcourues par une chaîne de triangles. Ces derniers, s'étendant sur plusieurs centaines de kilomètres, ayant chacun de leurs côtés (base) de 100 km et chaque triangle de la chaîne ayant une base commune avec au moins un autre triangle et deux angles ou points fixes en commun avec un autre triangle.

La méthode de la triangulation permit de définir la véritable forme de la terre dans les années 1730 et 1740 grâce à de grands arcs réalisés au Pérou et en Laponie. Restait à résoudre le problème de la taille de la terre, compliqué par le fait qu'elle n'était pas une sphère parfaite. Les premiers arcs développés en France, au Pérou, en Laponie, en Italie, en Afrique du Sud et en Autriche présentaient tous des inconvénients qui ne permettaient pas de trouver une solution exacte au problème.

La défaite de Napoléon, suivie de la conférence de Vienne et de la décision en 1815 d'établir des frontières internationales en Europe requérait l'établissement de cartes précises. Les monarques européens ne croyaient plus à une paix durable et avaient besoin d'une cartographie précise pour des raisons militaires. Le tsar Alexandre Ier de Russie était particulièrement intéressé par cela et fournit à l'astronome Wilhelm Struve toutes les ressources pour mener à bien le projet d'un nouvel arc géodésique. On peut considérer que c'est la première étape du développement de la géodésie et de la topographie moderne

À cette époque, un arc très long avait été mesuré en Inde par Lambton et Everest, dont l'étude se termina en 1840. Un autre arc plus court avait été mesuré en Lituanie, par Carl Tenner. Struve connaissait ces arcs et eut communication des résultats (deux arcs de grande longueur sont nécessaires pour définir avec exactitude la forme et les dimensions de la terre). Struve travaillait à l'université Dorpat (Tartu) de l'actuelle Estonie et décida que l'arc qu'il allait établir suivrait une ligne de longitude (un méridien) qui passerait par l'observatoire de l'université. Le nouveau grand arc, appelé par la suite « arc de Struve » fut finalement établi en reliant des arcs plus petits précédemment établis avec un arc mesuré par Tenner dans le sud, ainsi que leurs extensions au nord et au sud. L'arc couvrait donc une ligne de 2800 km reliant Fuglenaes près de Hammerfest dans le grand Nord à Staro-Nekrasowka, près d'Ismail, sur les rives de la mer Noire. L'arc traverse aujourd'hui dix pays différents.

La proposition d'inscription comprend 34 des points fixes d'origine établis par Struve et ses collègues entre 1816 et 1851 afin d'établir l'arc de Struve (voir liste en annexe).

Il existe 4 points en Norvège, 4 en Suède, 6 en Finlande, 1 en Russie, 3 en Estonie, 2 en Lettonie, 3 en Lituanie, 5 en Belarus, 1 en Moldavie et 4 en Ukraine.

La description complète de chacun de ces 34 points est donnée dans le dossier de proposition d'inscription. En général, ce sont des points aux marquages différents que l'on pourrait décrire comme suit :

- De petits trous percés dans la roche, parfois remplis de plomb.

- Des marques en forme de croix gravées à la surface de la roche.

- Des pierres et des briques portant un repère.

- Des cairns avec une pierre ou une brique centrale marquée par un trou perforé.

- Une seule brique.

- Un « monument » spécialement construit pour commémorer le point et l'arc.

Politique de gestion

Chacun des pays de la proposition d'inscription a sa propre politique de gestion du patrimoine. Parallèlement, les dix pays ont défini un mécanisme de gestion commune sous la forme d'un comité de coordination chargé de coordonner la gestion des sites proposés pour inscription.

Nombre des « sites » proposés sont des points construits en pierre ou d'autre nature, entourés d'une très petite zone aménagée. La plupart d'entre eux font encore partie du système géodésique national et, à ce titre, ils ont une utilité potentielle et une importance pratique. Ils sont donc à la fois gérés par les services géodésiques nationaux et contrôlés par les institutions chargées du patrimoine culturel.

L'existence d'une protection légale et d'une gestion active sont deux des critères utilisés par les États parties pour choisir les 34 points parmi les nombreux points de l'arc de Struve.

Dispositions légales :

Tous les points suggérés sont protégés par la loi et, dans la plupart des cas, par deux lois, celle qui protège les points géodésiques et celle qui protège le patrimoine culturel.

Ressources :

Les ressources financières sont fournies pour la plupart par les services géodésiques, dans le cadre d'une activité régulière d'entretien des points géodésiques en usage. Ces services sont également responsables de l'entretien régulier des sites. En général, les États parties ne prévoient pas de financements supplémentaires au cas où les sites seraient inscrits sur la Liste du patrimoine mondial. Des financements seraient requis pour apposer des plaques et améliorer la présentation.

Justification émanant des États parties (résumé)

Définir la taille et la forme de la terre fut l'un des problèmes les plus importants que se posa la philosophie naturelle au moins depuis le IVe siècle av. J.-C.. Au XVIIe siècle, la mise au point d'un système de mesure appelé « triangulation » améliora la capacité à déterminer la taille et la forme de la terre. Grâce au système de longues chaînes de triangles, des « arcs » s'étendant sur des milliers de kilomètres furent mesurés. L'arc géodésique de Struve est l'un d'entre eux.

Il est impossible de dresser une carte exacte sans l'aide des stations de triangulation. Aucune navigation, aucun plan, aucune cartographie n'est possible sans l'établissement de cartes précises. Les arcs ont contribué au développement de ce système et à sa précision.

L'arc de Struve est remarquable par sa longueur (plus de 2820 km) et sa précision. Seul un arc réalisé en 1954 le dépasse en longueur. Sa précision est de 4 millimètres par kilomètre. Il a aidé au développement de nouveaux équipements de mesure plus précis et, indirectement, à la « promotion » du système métrique. C'est la première mesure d'un méridien traversant les frontières de plusieurs pays, au nombre de dix aujourd'hui. Il servit de base pour l'établissement des cartes des pays qu'il traversait ainsi que de l'Europe centrale de l'est.

Critères proposés :

Critère ii : Le site témoigne d'un échange important de valeurs humaines de collaboration entre les scientifiques de différents pays. Il présente une phase importante du développement des sciences de la terre et de l'usage des technologies.

Critère iii : L'arc apporte un témoignage unique sur la mesure de la terre sur une période de trois siècles, utilisant la trigonométrie et les observations astronomiques sur les longitudes.

Critère iv : Les points de l'arc constituent un exemple éminent du développement extraordinaire de la science et de la connaissance de la terre.

Critère vi : Les points de l'arc sont associés à la théorie d'Isaac Newton qui disait que la terre n'est pas une sphère parfaite mais plutôt une sphère oblongue.

3. ÉVALUATION DE L'ICOMOS

Actions de l'ICOMOS

Une mission d'expertise de l'ICOMOS a visité les sites en août 2004 et un représentant de l'ICOMOS a participé à une conférence sur le « Futur de l'arc géodésique de Struve » qui s'est déroulée en septembre 2004.

L'ICOMOS a également reçu des évaluations scientifiques et a consulté le CIPA, son Comité scientifique international sur la documentation du patrimoine.

Conservation

Les différents points proposés pour inscription sont en bon état de conservation. Nombre d'entre eux font encore partie du réseau national géodésique et sont entretenus régulièrement.

Historique de la conservation :

L'importance historico-culturelle de certains points est reconnue depuis longtemps et beaucoup d'entre eux sont protégés par des lois nationales portant sur le patrimoine culturel des pays. En tant que monuments reconnus, toutes les règles s'appliquent, notamment celles qui concernent la conservation. La plupart des points ont perdu leur plaque d'origine ou le plomb bouchant les trous. Certaines ont été réinstallées, à l'emplacement d'origine.

Gestion :

Les sites sont correctement gérés.

Analyse des risques :

Le seul risque potentiel pourrait découler de visites trop nombreuses dues à l'inscription sur la Liste du patrimoine mondial. Ce type de risque est à prendre en considération par le nouvel organe de coordination créé par les États parties.

Authenticité et intégrité

Ce point n'est quasiment pas applicable en raison des caractéristiques particulières et de la valeur du bien proposé pour inscription. Tous les points se trouvent à leur emplacement d'origine, certains se trouvent dans des lieux isolés qui n'ont pas changé depuis la création de l'arc.

Évaluation comparative

Il y a eu des arcs avant celui de Struve et il en existe de plus longs aujourd'hui. Néanmoins, au moment de sa création, l'arc de Struve était le plus long et le plus précis de tous les arcs. Il est resté le plus long pendant plus d'un siècle. Il fut le premier pour lequel un matériel spécial fut créé et le premier à traverser plusieurs pays.

Valeur universelle exceptionnelle

Déclaration générale :

L'arc de Struve a sans aucun doute une valeur universelle exceptionnelle, basée sur sa contribution au développement des sciences et pour la collaboration qu'il suscita entre les scientifiques, les monarques et les nations.

L'ICOMOS pense que cette proposition d'inscription possède une valeur supplémentaire car elle est basée sur des valeurs technologiques et scientifiques et elle est soumise par dix États parties.

Une extension de cette proposition pour inclure l'arc qui le relie à l'Afrique du Sud devrait être envisagée dans le futur.

Évaluation des critères :

La proposition d'inscription remplit les critères ii, iv et vi.

Le critère iii ne s'applique pas.

4. RECOMMANDATIONS DE L'ICOMOS

Recommandation concernant l'inscription

L'ICOMOS recommande que le Comité du patrimoine mondial adopte le projet de décision suivant :

Le Comité du patrimoine mondial,

1. Ayant examiné le document WHC-05/29.COM/8B,

2. Inscrit le bien sur la Liste du patrimoine mondial sur la base des ***critères ii, iv et vi*** :

> ***Critère ii*** : La première mesure précise d'un long segment d'un méridien qui a permis d'établir la taille et la forme exactes de la terre illustre une phase importante du développement des sciences de la Terre. C'est également un exemple remarquable d'un échange de valeurs humaines sous la forme d'une collaboration entre des scientifiques de différents pays. C'est aussi une illustration de la participation de monarques de différentes puissances à une cause scientifique.
>
> ***Critère iv*** : L'arc géodésique de Struve est sans aucun doute un exemple exceptionnel d'un ensemble technologique, illustrant les points de triangulation de la mesure d'un méridien et constituant la partie fixe et immatérielle des techniques de mesure.
>
> ***Critère vi*** : La mesure de l'arc et ses résultats sont directement associés aux questionnements de l'homme sur la taille et le forme de la terre. Elle est liée à la théorie d'Isaac Newton qui déclarait que la terre n'est pas une sphère parfaite.

ICOMOS, avril 2005

Site No	NOM D'ORIGINE Nom actuel	État partie
1	**FUGLENAES** Fuglenes	Norvège
2	**LILLE-REIPAS** Raipas	Norvège
3	**LOHDIZHJOKKI** Luvdiidcohkka	Norvège
4	**BÄLJATZ-VAARA** Baelljasvarri	Norvège
5	**PAJTAS-VAARA** Tynnyrilaki	Suède
6	**KERROJUPUKKA** Jupukka	Suède
7	**PULLINKI** Pullinki	Suède
8	**PERRA-VAARA** Perävaara	Suède
9	**STUOR-OIVI** Stuorrahanoaivi	Finlande
10	**AVASAKSA** Aavasaksa	Finlande
11	**TORNEA** Alatornion kirkko	Finlande
12	**PUOLAKKA** Oravivuori	Finlande
13	**PORLOM II** Tornikallio	Finlande
14	**SVARTVIRA** Mustaviiri	Finlande
15	**MÄKI-PÄÄLYS** Mäkipällys	Russie
16	**HOGLAND, Z** Gogland, Tochka Z	Russie
17	**WOIBIFER** Võivere	Estonie
18	**KATKO** Simuna	Estonie
19	**DORPAT** Tartu Observatory	Estonie
20	**SESTU-KALNS** Ziestu	Lettonie
21	**JACOBSTADT** Jekabpils	Lettonie

22	**KARISCHKI** Gireišiai	Lituanie
23	**MESCHKANZI** Meškonys	Lituanie
24	**BERESNÄKI** Paliepiukai	Lituanie
25	**TUPISCHKI** Tupishki	Belarus
26	**LOPATI** Lopaty	Belarus
27	**OSSOWNITZA** Ossovnitsa	Belarus
28	**TCHEKUTSK** Chekutsk	Belarus
29	**LESKOWITSCHI** Leskovichi	Belarus
30	**RUDY** Rudi	Moldavie
31	**KATERINOWKA** Katerinowka	Ukraine
32	**FELSCHTIN** Felschtin	Ukraine
33	**BARANOWKA** Baranowka	Ukraine
34	**STARO-NEKRASSOWKA** Stara Nekrasivka	Ukraine

Plan indiquant la localisation du bien proposé pour inscription

L'observatoire de Tartu - Tartu, Estonie – Dorpat (19)

Le monument à la limite septentrionale de l'arc - Fuglenaes (1), Norvège