ANNEX

Annex C.1

List of Tree and Bush Species that Recommended for Planting and Creation of Green Zone of Astana City

No.	Names of species				Ave. height m	Period of live years	grow speed	Desti-nation	Evergreen deciduous	Form of crown	Color of leafs, needle (autumn)	Stability	Market-ability
	Russian		scientific, Latin										
		Trees											
1	Birch	karelian	Betula	carelica	15	150	4	2	deciduous	oval	yellow	1,4,5,8,10	rare
2	Birch	common	Betula	pendula	20	80	1	2.5	deciduous	weeping	yellow	1,4,5,8,9	highly
3	Birch	asian white	Betula	platyphylla	20	100	1	2.5	deciduous	oval	yellow	1,4,5,8,9	highly
4	Elm	Russian	Ulmus	laevis	20	200	1	1,2,4,5	deciduous	oval	yellow brown	2,3,5,7,9	highly
5	Elm	Scotch	Ulmus	scabra	20	200	1	1,2,4,5	deciduous	oval	yellow brown	2,3,5,7,9	highly
6	Elm	pinnate-branched	Ulmus	pinnatoranosa	15	100	1	3.5	deciduous	spherical	yellow	2,3,5,7,9	highly
7	Elm	п р и з е м и с т ы й	Ulmus	pumila	12	100	2	2,3,4,5	deciduous	oval	yellow	2,3,5,7,9	highly
8	Pear	Ussuri	Pyrus	ussuriensis	8	200	4	2.5	deciduous	pyramidal	purple	1,4,5,8,9	highly
9	Oak	pedunculate	Quercus	robur	20	400	3	2.4	deciduous	spherical	tanned	1,4,6,8,9	rare
10	Spruce	red	Picea	rubrum	20	300	4	2.4	evergreen	conical	dark green	2,4,5,8,9	rare
11	Spruce	white	Picea	canadensis	25	350	4	2.4	evergreen	conical	silver	2,4,5,8,9	rare
12	Spruce	Norway	Picea	abies	25	300	2	2.4	evergreen	conical	darkgreen	2,4,5,8,9	highly
13	Spruce	Siberian	Picea	obovata	25	250	3	2,4,5	evergreen	conical	green	2,4,5,8,9	highly
14	willow	white	Salix	alba	20	80	1	1,2,5	deciduous	weeping	yellow	1,4,5,8,9	highly
15	willow	hybrid	Salix	gibridensis	20	60	1	1,2,5	deciduous	spherical	yellow	1,4,5,8,9	highly
16	willow	crack	Salix	fragilis	15	80	1	1,2,5	deciduous	weeping	yellow	1,4,5,8,9	highly
17	willow	daphne	Salix	daphoides	15	50	1	2.5	deciduous	spherical	yellow	1,4,5,8,9	highly
18	Maple	Norway	Acer	platanoides	20	200	3	2	deciduous	round	red violet	1,4,6,8,10	rare
19	Maple	riverside	Acer	ginnala	5	100	2	2.5	deciduous	round	carmine	2,4,5,8,9	highly
20	Maple	Tatar	Acer	tatarika	10	100	2	1,2,4,5	deciduous	round	red violet	2,3,5,7,9	highly
21	Maple	ash-leaved	Acer	negundo	20	80	1	1,2,4,5	deciduous	branchy	many-colored yellow	2,3,6,7,9	highly
22	Larch	Dahurian	Larix	dahurica	30	400	2	2	coniferous, adscession	outstretched	lightly green	1,4,5,8,9	rare
23	Larch	Lyubarsky's	Larix	Lubarskogo	30	400	2	2	coniferous, adscession	conical	lightly yellow	1,4,5,8,9	rare
24	Larch	Siberian	Larix	sibirika	30	450	2	2.5	coniferous, adscession	conical	brightly yellow	1,4,5,8,9	highly
25	Larch	Sukachev's	Larix	Sukaczewii	30	400	2	2.5	coniferous, adscession	conical	brightly yellow	1,4,5,8,9	highly
26	Larch	Chekanovsky's	Larix	Czekanowskogo	30	450	2	2	coniferous, adscession	conical	lightly green	1,4,5,8,9	rare
27	Larch	Japanese	Larix	ieptolepis	20	400	2	2	coniferous, adscession	conical	blue-green	2,4,5,8,9	rare
28	Linden	Amur	Tilia	amurensis	20	200	3	2.4	deciduous	round	yellow	2,4,5,8,10	rare
29	Lime	large-leaved	Tilia	platyphyllos	25	500	3	2.4	deciduous	pyramidal	yellow	2,4,5,8,9	rare
30	Lime	small-leaved	Tilia	cordata	20	300	3	2,4,5	deciduous	oval	golden yellow	2,4,5,8,9	highly

No.	Names of species				Ave. height m	Period of live years	grow speed	Desti- nation	Evergreen deciduous	Form of crown	Color of leafs, needle (autumn)	Stability	Market- ability
	Russian		scientific, Latin										
31	Lime	Siberian	Tilia	sibirica	25	300	3	2.5	deciduous	oval	yellow	2.4.5.8.9	highly
32	Silverberry		Elaeagnus	argentea	8	50	1	2,4.5	deciduous	branchy	silver	1.4.5.7.9	highly
1	2	3	4	5	6	7	8	9	10	11	12	13	14
33	Olive	Russian	Elaeagnus	angustifolia	8	50	1	2.4.5	deciduous	branchy	silver	1.3.5.7.9	highly
34	Fir	silver	Abies	alba	25	200	3	1.2.4	evergreen	conical	darkly green	2.4.5.8.10	rare
35	Fir	Siberian	Abies	sibirica	30	150	3	1.2.4	evergreen	conical	darkly green	2.4.5.8.10	highly
36	Mountain ash	Amur	Sorbus	aucuparia	8	70	3	2.4.5	deciduous	oval	red	1.4.5.8.10	rare
37	Mountain ash	common	Sorbus	aucuparia	15	80	3	2.4.5	deciduous	oval	red	1.4.5.8.10	highly
38	Mountain ash	Siberian	Sorbus	aucuparia	7	80	3	2.4.5	deciduous	oval	red	1.4.5.8.9	highly
39	Blackthorn		Prunus	spinosa	6	100	2	2	deciduous	egg-shaped	purple	1.4.5.8.9	highly
40	Plum	Ussuri	Prunus	ussuriensis	8	100	2	2	deciduous	egg-shaped	yellow	1.4.5.8.9	rare
41	Pine	Scots	Pihus	silvestris	30	350	2	2.4.5	evergreen	round	green	1.3.5.8.10	highly
42	Pine	shore	Pihus	contorta	25	400	3	2	evergreen	branchy	green	1.3.5.8.10	rare
43	Poplar (aspen)	trembling	Populus	tremula	25	100	1	2.5	deciduous	round	purple	2.4.5.7.9	н и з к а я
44	Poplar	balsam	Populus	balsamifera	30	150	1	5	deciduous	egg-shaped	yellow	2.4.5.7.9	н и з к а я
45	Poplar	white	Populus	alba	30	100	1	2.4.5	deciduous	oval	yellow	2.4.5.8.9	highly
46	Poplar	laurel	Populus	laurifolia	25	100	1	2.5	deciduous	egg-shaped	yellow	2.4.5.7.9	highly
47	Poplar	Kazakhstan	Populus	kazakhstan	28	100	1	2.4.5	deciduous	conical	yellow	2.4.5.7.9	rare
48	Arbor-vitae	American	Thuja	cocidentalis	6	150	3	2.4	evergreen	pyramidal	green brown	2.4.5.8.9	highly
49	Chokeberry	Asian	Padus		10	100	2	2	deciduous	oval	yellow	2.4.5.8.9	rare
50	Chokeberry	common	Padus	virginiana	8	100	2	2.4.5	deciduous	egg-shaped	red	2.4.5.8.9	highly
51	Bird cherry		Padus	racemosa	10	100	2	2.4.5	deciduous	branchy	yellow	2.4.5.8.9	highly
52	Crab-apple	Siberian	Malus	sibirika	7	100	4	2.4.5	deciduous	round	bronzy	2.4.5.8.9	highly
53	Apple	wild	Malus	silvestris	10	100	4	2.4	deciduous	round	bronzy	2.4.5.8.9	highly
54	Ash	green	Fraxinus	lanceolata	15	250	2	2.4.5	deciduous	pyramidal	yellow	1.4.6.8.9	highly
		Bushes											
1	Chokeberry	black	Aronia	melanocarpa	3	70	3	2.4	deciduous	oval	yellow red	2.4.5.8.9	highly
2	Hawthorn	Altai	Grataegus	altaica	5	250	2	1.2.3.5	deciduous	branchy	orange	1.4.5.8.9	rare
3	Hawthorn	Arnold's	Grataegus	Arnolda	6	300	2	1.2.3.5	deciduous	oval	red brown	1.4.5.8.9	rare
4	Haw	red	Grataegus	sanguinea	6	300	2	1.2.3.5	deciduous	oval	red	1.4.5.8.9	highly
5	Hawthorn	Maximovich's	Grataegus	Maximowiczii	7	250	2	1.2.3	deciduous	oval	red	1.4.5.8.9	rare
6	Hawthorn	(with green flesh)	Grataegus		5	200	2	1.2.3	deciduous	oval	red	1.4.5.8.9	rare
7	Hawthorn	Almaty	Grataegus	almaatensis	5	200	2	1.2.3	deciduous	oval	red brown	1.4.5.8.9	rare
8	Hawthorn	common	Grataegus	ocsicanta	6	300	2	1.2.3.5	deciduous	oval	red brown	1.4.5.8.9	highly
9	Hawthorn	pinnate	Grataegus	pinnatifida	6	250	2	1.2.3	deciduous	oval	red	1.4.5.8.9	rare
10	Hawthorn	Shreder's	Grataegus	Schredera	5	250	2	1.2.3	deciduous	oval	red brown	1.4.5.8.9	rare
11	Elder	red-berried	Sambucus	racemosa	3	30	1	2	deciduous	round	yellow	2.4.6.8.9	low
12	Barberry	common	Berberis	vulgaris	1.5	60	2	2	deciduous	oval	golden red	1.4.5.8.9	highly
13	Barberry	Siberian	Berberis	sibirika	0.5	70	2	2	deciduous	oval	red	1.4.5.8.9	highly
14	Barberry	Japanese	Berberis	tunbergii	2.5	50	2	2	deciduous	oval	carmine	1.4.5.8.9	rare
15	Spindle-tree	warty-barked	Euonymus	verrucosa	2	70	2	2	deciduous	round	red yellow	2.4.6.8.9	rare

No.	Names of species				Ave. height m	Period of live years	grow speed	Desti-nation	Evergreen deciduous	Form of crown	Color of leafs, needle (autumn)	Stability	Market-ability
	Russian		scientific, Latin										
16	Spindle-tree	European	Euonymus	europaea	5	70	2	2	deciduous	round	red yellow	2,4,6,8,9	rare
1	2	3	4	5	6	7	8	9	10	11	12	13	14
17	Cherry	Bessey	Cerasus	Besseyi	1	50	2	2.5	deciduous	outstretched	brown	1,4,5,8,9	highly
18	Cherry	nanking	Cerasus	tomentosa	1.5	50	2	2.5	deciduous	round	brown	1,4,5,8,9	highly
19	Cherry	ground	Cerasus	frutcosa	1	50	2	2.5	deciduous	outstretched	red brown	2,4,5,8,9	highly
20	Hydrangea	panicled	Hydrangea	panicuata	2	60	2	2	deciduous	oval	yellow	1,4,6,8,10	rare
21	Dogwood	tartar	Cornus	alba	2	70	2	2.5	deciduous	round	brown	2,4,5,8,9	highly
22	Greenweed	dyer's	Genista	tinctoria	1	100	2	2.5	deciduous	sheaf-like	yellow	1,3,5,7,9	rare
23	Jasmine	ground	Jasminum	fruticans	1.5	50	1	2	deciduous	round	yellow	1,4,5,8,9	rare
24	Honeysuckle	Alpine	Lanicera	alpica	1.5	40	2	2	deciduous	branchy	yellow	2,3,5,8,9	rare
25	Honeysuckle	Altai	Lanicera	altaica	3	30	2	2	deciduous	branchy	yellow	2,3,5,8,9	rare
26	Honeysuckle	common	Lanicera	xylosteum	2	50	2	2	deciduous	round	yellow	2,3,5,8,9	low
27	Honeysuckle	Maack's	Lanicera	Maakii	2	50	2	2	deciduous	round	yellow	2,3,5,8,9	rare
28	Honeysuckle	Pallas's	Lanicera	Pallasiana	2	50	2	2	deciduous	round	yellow	2,3,5,8,9	rare
29	Honeysuckle	съедобная	Lanicera	edulis	1.5	30	2	2	deciduous	branchy	yellow violet	1,3,5,8,9	highly
30	Honeysuckle	sweet-berry	Lanicera	coerulea	1	30	2	2	deciduous	branchy	yellow	1,3,5,8,9	rare
31	Honeysuckle	Ruprekht's	Lanicera	Ruprechtiana	3	50	2	2	deciduous	branchy	yellow	1,3,5,8,9	rare
32	Honeysuckle	tartar	Lanicera	tatarika	2.5	60	2	2.5	deciduous	sheaf-like	yellow	2,3,5,7,9	low
33	Shadbush	Canadian	Amelanhier	canadensis	5	50	2	1,2,4,5	deciduous	branchy	red	2,4,5,8,9	rare
34	Shadbush	dwarf	Amelanhier	spicata	3	50	2	2	deciduous	branchy	red	2,4,5,8,9	highly
35	Shadbush		Amelanhier	ovalis	4	60	2	1,2,4,5	deciduous	branchy	red orange	2,4,5,8,9	highly
36	Willow	блестящая	Salix	alba	2	30	1	1,2,5	deciduous	sheaf-like	yellow	2,4,5,8,9	highly
37	Willow	Caspian	Salix	caspica	2	30	1	1,2,5	deciduous	sheaf-like	yellow	2,4,5,8,9	rare
38	Willow	purple	Salix	purpurea	1.5	40	1	5	deciduous	sheaf-like	yellow	2,4,5,8,9	low
39	Willow	Ledebur's	Salix	Ledebura	3	60	1	2	deciduous	sheaf-like	yellow	2,4,5,8,9	rare
40	Willow	sharp-leaved	Salix	acutifolia	2	30	1	5	deciduous	sheaf-like	yellow	2,4,5,7,9	rare
41	Guelder rose		Viburnum	opulus	4	50	2	2	deciduous	round	red orange	2,4,5,8,9	highly
42	Pea-shrub	гордовина	Viburnum	lantana	5	50	2	2	deciduous	oval	red	2,4,5,8,9	highly
43	Pea-shrub	yellow	Caragana	arborescens	4	100	1	1,2,3,5	deciduous	oval	yellow	2,3,5,7,9	highly
44	Pea-shrub	low	Caragana	pumila	2	80	1	2.3	deciduous	oval	yellow	2,3,5,7,9	highly
45	Cotoneaster	hedge	Cotoneaster	licidus	2	60	2	2	deciduous	oval	purple	2,3,5,8,9	rare
46	Cotoneaster	black-berried	Cotoneaster	melanocarpus	2	60	2	2	deciduous	branchy	redish	2,3,5,8,9	highly
47	Buckthorn	Pallas's	Frangula	Pallasiana	4	70	2	5	deciduous	oval	yellow	2,4,5,8,9	rare
48	Buckthorn	Ussuri	Frangula	ussuriensis	3	80	2	5	deciduous	oval	brown	2,4,5,8,9	rare
49	Buckthorn		Frangula	cathartica	4	80	2	5	deciduous	oval	brown	2,4,5,8,9	low
50	Almond	steppe	Amygdalus	nana	1.5	50	2	2.5	deciduous	oval	yellow	1,3,5,8,9	highly
51	Almond	Ledebur's	Amygdalus	Ledeburii	1.5	50	2	2	deciduous	oval	brown	2,3,5,8,9	highly
52	Juniper	common	Juniperus	communis	10	200	4	2	evergreen	round	green	2,3,5,8,9	highly
53	Savin		Juniperus	sabina	1.5	150	3	2	evergreen	decumbent	green	2,3,5,8,9	highly
54	Tamarisk	false	Muricaria	alopecuroides	1.5	100	4	2	deciduous	oval	yellow	1,4,5,8,9	rare
55	Buckthorn	sea	Hippophae	rhamnoides	3	80	3	2	deciduous	branchy	tanned	1,4,5,8,9	highly

No.	Names of species				Ave. height m	Period of live years	grow speed	Desti-nation	Evergreen deciduous	Form of crown	Color of leafs, needle (autumn)	Stability	Market-ability
	Russian		scientific. Latin										
1	2	3	4	5	6	7	8	9	10	11	12	13	14
56	Nine-bark	common	Physocarpus	opulifolia	2	50	3	2	deciduous	sheaf-like	yellow green	1.4.5.8.9	highly
57	Rose	Altai	Rosa	altaica	1.5	50	2	2	deciduous	sheaf-like	red brown	1.4.5.8.9	highly
58	Dogrose		Rosa	conina	1.5	50	2	2.3	deciduous	sheaf-like	red brown	2.3.5.8.9	низкая
59	Rose	Japanese	Rosa	rugosa	1.5	60	2	2.3	deciduous	sheaf-like	red brown	2.3.5.8.9	highly
60	Rose	рыхлая	Rosa	laxa	2	50	2	3	deciduous	sheaf-like	red brown	2.3.5.8.9	низкая
61	Rose	cinnamon	Rosa	cinnamomea	2	60	2	2.3	deciduous	sheaf-like	red brown	2.3.5.8.9	низкая
62	Rose	thorny	Rosa	spinosissima	5	60	2	2.3	deciduous	sheaf-like	red brown	2.3.5.8.9	низкая
63	Spiraea	urals false	Sorbaria	sorbifolia	2	50	2	2	deciduous	sheaf-like	purple	1.4.5.8.9	rare
64	Currant	golden	Ribes	aureum	2	30	2	2.5	deciduous	oval	yellow red	1.3.5.7.9	highly
65	Currant	black	Ribes	nigra	1.5	30	2	2	deciduous	oval	yellow	2.4.5.8.9	highly
66	Currant	red	Ribes	rubrum	1.5	40	2	2	deciduous	oval	yellow	2.4.5.8.9	highly
67	Lilac	Amur	Suringa	amurensis	5	100	2	2.4	deciduous	oval	yellow	2.4.5.8.9	rare
68	Lilac	Hungarian	Suringa	josikaea	3	80	2	2.4.5	deciduous	branchy	yellow	2.4.5.8.9	highly
69	Lilac	Wolf's	Suringa	Wolva	2	80	2	2	deciduous	oval	yellow	2.4.5.8.9	rare
70	Lilac	common	Suringa	vulgaris	5	100	2	2.4.5	deciduous	oval	yellow	2.4.5.8.9	highly
71	Lilac	late	Suringa	villosa	2	100	2	2	deciduous	oval	yellow	2.4.5.8.9	highly
72	Snow berry	white	Symphoricarpos	racemosus	1.5	50	2	2	deciduous	oval	yellow green	2.4.5.8.10	highly
73	Spiraea	snow	Spirea	crenata	1	20	1	2	deciduous	sheaf-like	red brown	1.3.5.8.9	rare
74	Aaron's beard		Spirea	salicifolia	2	20	1	2	deciduous	sheaf-like	yellow red	1.3.5.8.9	rare
75	Spiraea	сиренецветн	Spirea	suringifoliaceae	1.5	25	1	2	deciduous	sheaf-like	yellow	1.3.5.8.9	rare
76	Spiraea	oriental	Spirea	media	1.5	25	1	2	deciduous	sheaf-like	red brown	1.3.5.8.9	rare
77	Nine-bark	Amur	Spirea	trilobata	2	20	1	2	deciduous	sheaf-like	red brown	1.3.5.8.9	rare
78	Spiraea	зверобоелис	Spirea	hypericifolia	1.5	20	1	2	deciduous	sheaf-like	red brown	1.3.5.8.9	low
79	Spiraea	Japanese	Spirea	japonica	1.5	20	1	2	deciduous	sheaf-like	carmine	1.3.5.8.9	rare
80	Tamarisk	рыхлый	Tamarix	laxa	4	40	1	2.5	deciduous	branchy	yellow	1.3.5.7.9	rare
		Lianas											
1	Grapevine	wild	Vitis	silvestris	8	20	1	4	deciduous	climbing	lightly yellow	1.4.6.8.10	highly

Note: there is an abbreviation in the list

Speed of growth:

Trees

1. Very fast growing (growth more than 1m)
2. Fast growing (growth 0.6 -1m)
3. Average growing (growth 0.3-0.5m)
4. Slow growing (growth up to 0.3m)

Bushes

1. Very fast growing
2. Fast growing
3. Slow growing

Destination:

1. Land-mark tree
2. Landscape
3. Green hedge
4. Shadow tree
5. Sanitary&protection zone

Stability

1. Light-requiring
2. Shadow enduring
3. Drought-resistant
4. Hygrophilous (moisture requiring)
5. Frost-resisting
6. Freeze slightly
7. Salt-resistant
8. Cannot resist soil salinization
9. Resistant to air pollution
10. Cannot resist air pollution

Annex C.2

Extracts from "Regulations on establishment, maintenance and protection of green plantations in Astana City"Prepared by V.P.Bobrovnik(2000).

2.2Tentative forestation zoning of Astana City territory.

Forestation conditions in Astana City are different. It conditions variety of works on greenery planting and landscaping. Classification by quality and area shown below was implemented by us with application of soil data of 1962-63 and 1996, hydrological materials of 1986 and 1989, as well as results of the reconnaissance survey of the territory of Astana. As per this classification the following areas were determined by groups of forest-growing conditions:

I. Best conditions for forest growing (quality below the average) comprise 3 regions:

- Starting from Mozhaisky Street between Seifullin and Kenesary Streets up to Bukeikhan Street and further the narrow strip stretches up to the corner of Sary-Arka and Ishimskaya Streets. This is a flat plain slightly sloping southwestward. Level of ground water is 3-4 m (in some places 1.7-2.2 m), ground water mineralization is 2.7-8.4 g/l. Occurrence depth of mottled saline waterproof clays – 3m. This area is suitable for creation of phytocenoses of all the plants recommended for the city. Thickness of drainage-screening layer for trees is 25-35 cm, for shrubs – 15-25 cm.
- Region in the central-western part of the city stretches from Moskovskaya Street in the north to Panfilov Street in the south and further turns southwestward between Zheltoksan Street and Pobeda Avenue up to Krasnoarmeiskaya Street. In the east the region is confined by Pushkin Street and in the west – by Sary-Bulak riverbed. Occurrence depth of saline mottled clays is 1-2 m in the western part of the area, and in the eastern part – 2-3 m. Ground water occurrence level is 0.5-0.9-1.5 m. These are conditions of below the average suitability for forests. The same plants as in the 1st region can be planted here. But preferable are plants with shallow rootage (especially in the western part).
- Narrow strip along the bank of Ishim River stretches from Korkyt Street to Sary-Bulak riverbed. Ground water level is 0.8-1-2 m. Occurrence depth of saline clays is 3 m in the east and 2-3 m in the west. Conditions and technology of planting, seeding are analogous to those applied in the previous region.

II. Group of satisfactory conditions, low suitability for forest growing. Includes several regions:

- Strip initiates in the northeast from the crossing point of Kazakhskaya Street and Dzhangildin Street stretching up to the corner of the former Kommunisticheskaya Street and Zheltoksan Street in the southwest. Ground water level is 2-3.5 m, occurrence depth of saline clays is 1-2 m. It is possible to establish plantations here using all the species recommended for the city, but more preferable are the plants more resistant to unfavorable soils and with shallow rootage. Thickness of drainage-screening layer is 30-40 cm.
- The region in the northeast: a strip stretching northward from Seifullin Street to the railroad. In the west the region is confined by Syrdaria Street, in the east – by Likhachyov Street. Ground water level in the west is 4 m, in the east – 1.6-1.8 or 3 m. Ground water mineralization is 5-6 g/l. Occurrence depth of saline clays is 3 m. Forestation conditions are satisfactory, similar to those of the previous regions.

III. Conditions of very low quality, very low suitability for forest growing, comprise several regions:

- Rather vast region is located in the northwest of the city: starting from Moskovskaya Street and Astrakhanskoye Highway, in the south encompassing Novaya, Dulat, Krivoguz Streets and stretching up to Lunin, Lesozavodskaya Streets in the northwest and Gogol and Ugolnaya Streets in the north. Here ground waters occur close to the surface – 0.8-1 m; their mineralization is 9.8-39 g/l. Saline waterproof clays also occur close to the surface – 0-1-2 m. Accumulation of water can be observed in some places on the surface. Processes of swamping, salinization and intensive impoundment are ongoing. The forestation conditions are very low, that is drainage and lowering of ground water level is necessary. Plantations should be established in holes, trenches or on the surface. Thickness of the drainage-screening layer is 45-50 cm. It is expedient to use plant species resistant to salinization and water: willows, poplars, elms, maples, silverberry *(Elaeagnus argentea)*, Tartar honeysuckle *(Lonicera tatarica)*, Golden currant *(Ribes aureum)*, acacia and rose species.
- There is a small region in the middle of western part of the city. Latitudinal strip between Dzhangildin and Seifullin Streets turns southwestward between Pobeda Avenue and Kolkhoznaya Street and stretches up to Ishimskaya Street in the south. Ground water level is 0.8-1.2 m, occurrence depth of saline clays is 2-3 m. Territory of the mentioned region is drained a little better: impoundment and salinization take

place on a lesser scale. Here the assortment of plants can be increased to some extent by addition of hawthorn *(Crataegus)*, Ussuri pear *(Pyrus ussuriensis)*, apple tree, lilac, Ground cherry *(Prunus fruticosa)*, etc.

- Broad region in the southwestern part of the city: to the west of Kulturnaya Street and westward of the valley of Sary-Bulak River. Ground water level is 0-1-2 m, occurrence depth of saline clays – 1-3 m. Conditions are similar to the previous region. Conditions are rather unfavorable for greenery planting in Manas Street, Abylai-khan Avenue (from the bridge to the building No.6 and a spot at size of 1200-2000 m further eastward of the bridge).

So, on the territory of Astana City several main forest-growing regions can be marked:

1. To the north and northwest of Manas Street, to the west of Pobeda Avenue, along Manas Street, to the south of Tarkhan Street. This is the region with the most difficult unfavorable conditions for forest growing. Here greenery planting will be the most costly and laborious. Mostly the works will have to be directed to supplementation, rehabilitation, and maintenance (repair) of existing plantations.
2. Central-western region stretches from Moskovskaya Street to the bank of Ishim River and up to Kenesary and Imanov Street in the south. In the west the region is confined by Sary-Arka Street and Pobeda Avenue, in the east – by Koshkarbayev Street. This is the region of low suitability for forest growing with high density of buildings. For conduction of planting works improvement of drainage system and correct designing of planting sites is required. Here all the plants recommended for planting in the city can be applied, but preferable are species with shallow rootage and less exigent to soil conditions.
3. Region with the most favorable conditions (below the average level) of forest growing conditions. It occupies the strip from Seifullin Street in the north and Kenesary and Imanov Streets in the south. In the west the region is confined by Valikhanov Street and stretches up to Mozhaisky Street in the east. The whole recommended assortment of species could be planted here. Thickness of the drainage-screening layer can be limited within 25-35 cm. Constraints for planting on this area are as follows: established infrastructures, high level of ground water, replacement of natural soils by grounds.

Annex C.3

Extracts from "CONDENCED VERSION FEASIBILITY STUDY ON CREATION OF THE BUFFER ZONE OF ASTANA CITY AND ESTABLISHMENT OF FOREST MELIORATION STATION" prepared by "KAZGIPROLESKHOZ" INSTITUTE

1.7. Land availability for forest growing

By physical-mechanical qualities, salinization degree, solonetzisity, moisture content, ground water level, presence of natural forests, and also by experience in tree growing the following groups of lands available for forest growing have been separated (Table1):

I group – lands available for forest growing guarantee growing of relatively stable and viable plants of majority trees of local flora;

II group – lands with limited availability for forest growing, appropriate for growing of salt-resistant species with the help of advanced agrotechnics;

III group – lands conditionally available for forest growing, appropriate for growing of the most salt-resistant species with the help of advanced agrotechnics. It's possible there to grow 4-5 m plants with lifetime of 10 years and preservation up to this age over 50%.

The critical condition for growing of vigorous enough trees and shrubs are coulisse planting in combination with spacing (water stores) and lifelong care.

I group – 11,899 hectares (37%) consists of dark chestnut, meadow-chestnut, meadow, not saline, slightly saline and slightly solonetzic types and complexes with not appropriate for this group components up to 50%, including those by watering conditions:

Ia – 8,620 hectares (27%) – automorphic (dark chestnut), where it's possible to grow the majority of local trees and shrubs;

Ib – 2,742 (8%) – semihydromorphic (meadow-chestnut) – appropriate for growing of water-resistant species;

Ic – 537 hectares (2%) – hydromorphic (meadow sols) – for plantation of water-resistant species.

Species, planted on the oils of the 1st type will have high stratum factors under the conditions of maintenance of lifelong rich soil and correct preplant soil treatment.

II group – lands with limited availability for forest growing – 2,283 hectares (7%) accumulates lands with medium degree of salinization. They are dark chestnut, meadow-chestnut, rarely- meadow soils of different salinization degree by profile. Only salt-resistant species can grow on these lands.

Agricultural measures on those lands should be primarily aimed at improvement of water delivering to plantations being grown, since excess of moisture leads to better adaptability of plants on saline soils, as well as at destruction of solid solonetzic bed.

III group – lands conditionally available for forest growing – 1,912 hectares (6%) – are heavily saline, slightly and medium diversities and their complexes. Only most drought-resistant and salt-resistant species could be grown on them without root reclamation.

Plants on such lands are not resistant and not long term.

IV group – lands not available for trees and shrubs growing - 9,221 hectares (22%) include solonetz, alkali lands and their complexes, and also boggy-meadow and heavily saline soils, cultivation of which will be possible only after handling root reclamation (drying of swamped grounds, washing up of heavily saline soils by means of drainage, gypsuming of solonetz soils).

There is a large tact (1800 hectares) of lands not appropriate for forest planting in the northern part of the territory, allocated for green zone. Cultivation of these lands is necessary in order to close the ring belt (ring) around Astana City from the side of prevailing winds. That is why it is proposed to conduct on that territory root reclamation followed by planting.

For treatment of aoutmorphic and semihydromorphic solonetz in the northern part of green zone most appropriate is reclamation that includes complex of chemical and agro-biological methods.

1.8. Experience in greenery planting and artificial afforestation

When planting greenery in Astana City previously most common species were Populus alba, Ulmus pinnatoramosa, Acer negundo etc. Planting of trees and shrubs inside the city as well as on datchas was done by putting saplings into holes with the help of advanced agrotechnics of land cultivation, partially with ground replacement and irrigation. The majority of city plantations is in satisfactory stages and has ornamental shape.

Only narrow strips and groups of shrubs in the flood-lands of Ishim River and near swamp depressions in over flood land terrace represent natural arboreous and shrub vegetation in the area of Astana.

Experience in greenery planting and protective afforestation for creation of green zone of Astana City could be observed on the example of Akmola forestry artificial plantations and existing forest belts along the highways and railways. All existing plantations in the area of Astana green zone allocation have been elaborated and described.

The best condition (II-III yield class, density 0.5-0.9) was detected in 2-6 row forest belts and coulisse plantations with wide (at least 20 m) inter-coulisse spaces, where continuous care for ground is maintained (plough of row-spacing and coulisse spacing up again) on dark chestnut soils of different texture (from slightly to heavily loamy), not saline and slightly alkali saline and slightly solonetzic ones.

In dense plantations (with row spacing of 2.5 m) oppression of arboreous species occurs together with dead top species.

In general, poor condition of forest crops could be explained by unfavorable soil qualities (density and dryness of ground beds, caused by solonetzicity) at weak agrotechnics and soil cultivation, and also by absence of soil treatment and care.

In 1904-1914 years silviculturist A.L.Adamovich has laid forest crops mainly Betyla verricosa and Pinus silvestris in "KrasnyYar" tract, situated 18 km to the southeast of Astana on meadow-chestnut loamy soils. At the present time these plantations on the area of 50 hectares are in good conditions (yield class III, density 0.4, content 8C2B) with dence underbrush of shrubs.

Analysis of forest growing conditions and experience in creation of greenery in the area of Astana City allow concluding the following:

- Forest growing conditions of the area of green zone allocation are characterized by unfavorable climatic conditions (dryness – moisture deficit, tensioned wind regime, severe frosts), mixed soil cover defined by compactness, salinization, solonetzicity, heavy texture, and essential participation of swamped territories. This requires selection of relatively drought-resistant and salt-resistant species, and application of specific agrotechnics of soil treatment, aimed at accumulation and preservation of moisture, desalinization, and on swamped areas – drainage, when creating the green zone;

- Moisture deficit stipulates forming of rarefied (low-dense) plantations, this is proved by experience in protective afforestation. Relatively rarified plantations (narrow strips combined with strip-spacing), where continuous care for ground is maintained (plough of row-spacing and inter-strips spacing), are in good conditions and safe.

CHAPTER D
HYDROGEOLOGY

SUPPORTING REPORT D: HYDROGEOLOGY

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D.1 Description of Relevant Aquifers as Groundwater Source

D.1.1 Akmolinsky Aquifer

The Akmolinsky aquifer, which extends about 60 km to the north of Astana and the northeastern sub-aquifer of the Akmolinsky aquifer, is located within the city. It is composed of four aquifers of the Carboniferous fissured limestone called Tournaisian sediments, as shown in Figure D.1.1 according to the exploration conducted during 1957 to 1966. The groundwater resources of the Akmolinsky aquifer estimated through the exploration during 1957 to 1966 is shown in the following table.

Groundwater resources of the Akmolinsky aquifer

Sub-aquifer of Akmolinsky aquifer*	Groundwater resources by degree of exploration (as of 1966)				
	Exploited	Confirmed	Potential		Total
	A	B	C_1	C_2	
A-1: Zholymbet	-	-	1.8	9.0	10.8
A-2: Sofievsky	-	1.7	14.4	-	16.1
A-3: Koyandinsky	-	15.0	-	-	15.0
A-4: Northeastern	4.1	2.5	1.6	-	8.2
Total	4.1	19.2	17.8	9.0	50.1

Unit: 1,000 m^3/day * limestone

There are 60 boreholes with depths of 100 to 150 m; 12 boreholes in the Zholymbetsky sub-layer, 18 boreholes in the Sofievsky sub-layer and 30 boreholes in the Koyandinsky sub-layer. Out of the 30 boreholes in the Koyandinsky sub-layer, 17 boreholes were developed for the Tselinograd city water supply from 1945 to 1968 before operation of the Vyacheslavskoye reservoir. A part of the well inventory and geo-chemical data of the Akmolinsky aquifer are shown in Tables D.1.1 and D.1.2.

According to the data of wells in the Akmolinsky aquifer, the yields range from 2 to 18 liter/sec with drawdowns of 2 to 21 m and the average water levels are 0.5 to 6.4 m below the ground surface. The average chemical contents of all soluble components called mineralization are 0.4 to 1.3 gram/liter. The operating wells in the northeastern sub-aquifer generally show deeper water table, less yield and higher mineralization comparing with other wells in the Akmolinsky aquifer.

D.1.2 Tselinogradsky Aquifer

The Tselinogradsky aquifer is composed of alluvial sands and gravels along the Ishim River. The Former State Department of Reserve Affairs (SDRA) in 1967 confirmed the amount of the groundwater resources to be 6,800 m^3/day as shown in the following table.

Groundwater resources of the Tselinogradsky aquifer

Sub-aquifer of Tselinogradsky aquifer*	Groundwater resources by degree of exploration (as of 1967)				
	Exploited	Confirmed	Potential		Total
	A	B	C_1	C_2	
B-1: Left bank	3.0	-	-	-	3.0
B-2: Right bank-1	-	-	2.1	-	2.1
B-3: Right bank-2	-	-	1.7	-	1.7
Total	3.0	-	3.8	-	6.8

Unit: 1,000 m^3/day * Alluvial sediments along the Ishim River

There were 40 boreholes with depths of 10 to 15 m; 18 boreholes in the left bank sub-aquifer, 12 boreholes in the right bank-1 sub-aquifer and 10 boreholes in the right bank-2 sub-aquifer. The groundwater levels were almost constant at depths of 3.1 to 4.5 m and the yields were 0.5 to 11.1 liter/sec with drawdowns of 3.5 to 5 m. The average mineralizations were 0.8 to 1.0 gram/liter, ranging from 1.2 gram/liter in the low level period to 0.3 gram/liter in the spring flood period.

The amount exploited by the 18 boreholes in the left bank sub-aquifer was about 3,000 m^3/day in the period of 1966 to 1973. These boreholes have never been utilized since 1973 and the groundwater levels seem to have recovered naturally.

D.1.3 Rozhdestvensky Aquifer

The Rozhdestvensky aquifer, which is located about 25 to 45 km away to the south of Astana City, is a composite of two types of aquifers, the Carboniferous limestone and Alluvial sediments as shown in Figure D.1.2. The groundwater resources of the two limestone sub-aquifers of the Rozhdestvensky aquifer estimated through the exploration of 1966-1968 is shown in the following table.

Groundwater resources of the Rozhdestvensky aquifer (limestone sub-aquifers)

Sub-aquifer of Rozhdestvensky aquifer	Groundwater resources by degree of exploration (as of 1966-1968)				
	Exploited	Confirmed	Potential		Total
	A	B	C_1	C_2	
C-1: Western*	-	-	4.7		4.7
C-2: Eastern*	-	-	-	3.2	3.2
Total	-	-	4.7	3.2	7.9

Unit: 1,000 m^3/day * Limestone

The sub-aquifers of the Carboniferous weathered limestone with widths of 1.0 to 1.5 km occur at depths of 5.8 to 31.1 m. There were 17 boreholes with depths of 100 to 150 m in the limestone sub-aquifers; 9 boreholes in the western sub-aquifer and 8 boreholes in the eastern sub-aquifer. The yields did not exceed 11.6 to 26.2 liter/sec with drawdowns of 5.9 to 13.8 m and the mineralizations range from 0.2 to 2.7 gram/liter.

The groundwater resources of the two alluvial sub-aquifers of the Rozhdestvensky aquifer estimated through the exploration as of 1966-1968 is shown in the following table.

Groundwater resources of the Rozhdestvensky aquifer (alluvial sub-aquifers)

Sub-aquifer of Rozhdestvensky aquifer	Groundwater resources by degree of exploration (as of 1966-1968)				
	Exploited	Confirmed	Potential		Total
	A	B	C_1	C_2	
C-3: Upper*	-	14.2	-	-	14.2
C-4: Lower*	-	22.0	-	-	22.0
Total	-	36.2	-	-	36.2

Unit: 1,000 m^3/day * Alluvial sediments along the Nura River

In the sub-aquifers of the alluvial sediments along the Nura River, there were 47 wells with depths of 15 to 20 m; 25 wells in the upper sub-aquifer and 22 wells in the lower sub-aquifer. The sub-aquifers occur at depths of 1 to 13.3 m. The yields range 1.7 to 10.3 liter/sec. The water levels range 1.1 to 11.6 m with an average of 6 m and the mineralization did not exceed 1.5 gram/liter. A part of the well inventory and geo-chemical data of the Rozhdestvensky aquifer are shown in Tables D.1.1 and D.1.2.

According to the data collected by the Akmola Hydrogeological Expedition from 1988 to 1990, phenol, oil products, mercury, sterol, and naphthalene contaminated the groundwater near the Nura River. The mercury contents in the alluvial sediments on the section of Rozhdestvenka-Mayly village range from 3.2 to 10.8 PLP with an average of 7 PLP according to the hydrogeological research which was conducted in 1997-1998 by JSC "Azimut". The flood plains in the Nura River contain 100 ton of mercury and 99 % of the mercury exists in the first 25 km section downstream of the Smarkandskoye reservoir near Karaganda according to the Kazakh State Architecture-Construction Academy. The mercury content shows the maximum during and after spring floods, because sludgy substances or sediments at the river bottom are moved up. The groundwater in the areas adjacent to the riverbeds contains mercury and the groundwater in the areas, which were irrigated by the river water of the Nura are also contaminated by mercury.

D.1.4 Nurinsky Aquifer

The Nurinsky aquifer, which is situated 80 km away to the southwest of the city near the village Sabyndy, is composed of alluvial deposits on the right bank terrace of the Nura River as shown in Figure D.1.3. The exploration in 1967 confirmed the amount of the groundwater resources to be 27,300 m^3/day as shown in the following table.

Groundwater resources of the Nurinsky aquifer

Aquifer	Groundwater resources by degree of exploration (as of 1967)				
	Exploited	Confirmed	Potential		Total
	A	B	C_1	C_2	
D: Nurinsky*	16.0	11.3	-	-	27.3

Unit: 1,000 m^3/day* Alluvial sediments along the Nura River

The groundwater has been exploited since 1967 and utilized for water supply of farms in the Korgalgi region through the pipeline of 900 km in length. There were 16 boreholes with depths of 25 to 35 m. The thickness of the aquifer ranges 1 to 30 m with an average of 16.5 m and the yields are 5 to 26 liter/sec with drawdowns of 0.7 to 4.6 m. The water levels are 2 to 8 m below the ground surface. The transmissivity of the aquifer is calculated to be 2,600 m^2/day and the storage coefficient is 0.15. The mean value of exploitation was 17,500 m3/day in 1980, 12,900 m^3/day in 1995 and 6,670 m^3/day in 1998. The mineralizations at the time of the groundwater exploration were observed to be 0.6 to 1.2 gram/liter and have increased to 0.8 or 1.5 gram/liter because of groundwater contamination as a result of the upstream industrial pollution. A part of the well inventory and geo-chemical data of the Nurinsky aquifer are shown in Tables D.1.1 and D.1.2.

TABLE

Table D.1.1 Well Inventory

Akmolinsky Aquifer

No	Construction year	Location of Screen (m)	Well Diameter (inch)	Rock of aquifer	Natural Water Level (m)	Yield (liter/sec)	Drawdown (m)	Mineralization (gram/liter)
1*	1958	23.0 - 100	8	Limestone	5.5	25.00	24.00	0.50
2*	1959	20.0 - 70.0	8	Limestone	8.5	22.00	19.80	0.30
3*	1959	20.0 - 50.0	8	Limestone	6.5	20.00	24.50	0.30
4*	1959	67.0 - 100	8	Limestone	14.0	9.00	48.00	**
5*	1959	67.0 - 100	10	Limestone	5.0	29.00	35.00	0.40
6*	1967	31.0 - 66.0	10	Limestone	20.0	11.00	16.00	0.24
7*	1967	37.0 - 57.0	10	Limestone	15.5	7.50	36.50	0.30
8*	1967	49.0 - 70.0	10	Limestone	19.4	4.50	50.60	0.15
9*	1967	41.0 - 65.0	10	Limestone	27.0	27.00	13.00	0.12
10*	1967	31.0 - 52.0	10	Limestone	18.7	8.50	25.10	0.12
I	1964	24.8 - 58.0	10	Limestone	18.0	15.10	23.50	-
II	1964	28.0 - 39.0	10	Limestone	14.0	2.50	22.04	-
III	1964	15.9 - 50.2	10	Limestone	10.0	7.20	14.00	-
IV	1964	25.6 - 57.7	10	Limestone	10.0	11.38	48.00	-
V	1964	27.5 - 58.6	10	Limestone	8.7	9.03	23.55	-
VI	1964	14.2 - 45.6	10	Limestone	7.8	3.44	33.40	0.43
VII	1964	22.7 - 80.0	10	Limestone	4.9	19.44	13.00	0.70
VIII	1964	18.8 - 59.6	10	Limestone	11.0	18.05	9.60	0.30
IX	1964	34.4 - 85.0	10	Limestone	17.0	9.61	15.37	0.30
251a	1964	37.9 - 62.5	10	Limestone	27.0	3.03	18.60	1.10

* : Pump station ** : not containing

Rozhdestvensky Aquifer

No	Construction year	Location of Screen	Well Diameter (inch)	Rock of aquifer	Natural Water Level (m)	Yield (liter/sec)	Drawdown (m)	Mineralization (gram/liter)
1	1974	4.0 - 13.0	8	Sand & gravel	4.0	5.00	1.00	1.00
2	1974	4.0 - 13.0	8	Sand & gravel	4.0	5.00	1.00	1.10
3	1974	4.0 - 13.0	8	Sand & gravel	4.0	5.00	1.00	1.00
4	1974	4.0 - 13.0	8	Sand	4.0	5.00	1.00	1.00
5	1974	4.0 - 16.0	8	Gravel & sand		5.00	1.00	1.10
6	1967	16.0 - 18.0	8	Gravel & pebble	3.0	15.00	22.00	1.00
7	1967	3.0 - 21.0	8	Gravel & pebble	3.0	5.00	2.00	1.30
8	1967	3.0 - 21.0	8	Gravel & pebble	3.0	5.00	2.00	1.00
9	1967	3.0 - 21.0	8	Gravel & pebble	3.8	4.00		1.30

Nurinsky Aquifer

No	Construction year	Location of Screen	Well Diameter (inch)	Rock of aquifer	Natural Water Level (m)	Yield (liter/sec)	Drawdown (m)	Mineralization (gram/liter)
1	1966	23.0 - 34.0	10	Gravel	8.12	18.30	14.88	0.80
2	1967	13.0 - 27.0	10	Gravel	8.90	11.70	8.94	0.90
3	1966	22.0 - 33.0	10	Gravel	3.65	28.30	5.80	0.80
4	1971	23.0 - 35.0	10	Sand	4.40	26.70	11.30	0.30
5	1966	21.0 - 33.0	10	Sand	5.95	16.70	13.82	0.70
6	1966	20.0 - 32.0	10	Gravel	8.45	25.00	10.36	0.40
7	1966	20.0 - 32.0	10	Gravel	6.30	23.60	9.26	0.40
8	1969	23.0 - 33.0	10	Sand	4.12	15.30	12.90	0.60
9	1971	15.0 - 30.0	10	Sand	6.20	13.90	10.70	0.60
10	1971	18.0 - 33.0	10	Sand & gravel	6.70	25.00	10.70	0.50
12	1971	20.0 - 33.0	10	Sand & gravel	5.70	22.50	4.98	1.40
13	1974	17.0 - 33.0	10	Sand & gravel	6.00	13.90		0.70
14	1986	21.0 - 36.0	10	Sand & gravel		21.70	4.70	
15	1986		10	Sand & gravel		17.20	2.20	
16	1990	15.0 - 37.0	10	Sandstone		30.00		
17	1979	20.0 - 36.0	10	Sand		22.20	10.50	1.5
18	1987	20.0 - 40.0	10	Sand		20.00		
19	1987	14.6 - 30.2	10	Sand		10.00		0.9
20	1989	19.8 - 39.8	10	Detritus		11.70		
21	1991	20.0 - 36.0	10	Sand		21.70		
22	1987	20.0 - 33.0	10	Sand		20.00		0.3

Table D.1.2 Geo-Chemical Data of Groundwater

Akmolinsky Aquifer

No	pH	Solid residue	Cation (mg/liter)				Anion (mg/liter)					Hardness (mg equivalent)	O_2 (mg/liter)
			Na + K	Ca	Mg	Fe	Cl	SO_4	HCO_3	NO_2	No_3		
1	7.3	539	64	60	24	0	99	48	244			5	
2	7.0	299	14	44	17	*	35	31	158			3.6	4.6
3	7.4	328	51	32	15	0	85	36	109	0	0	2.8	
5	7.0	376	48	36	24	0	114	45	109	0	0	8.1	
6	7.1	235	0	8	49	0	7	96	*	0	0	6.8	1.55
7	7.2	252	28	40	12		92	38	*	0	0	3	1.2
8	7.5	153	2	12	19		24	44	*	0	0	2.1	0.77
9	7.4	118	10	8	15	0	29	24	*	0	0	1.6	1
10	7.5	118	0	14	10		24	28	*	0	0	1.4	1.08
VI		426	110	18	11	2.8	90	106	183				
VII		706	135	54	3	3.8	200	148	268			5.5	
VIII		304	18	36	23	*	30	82	132			3.7	2
IX		321	30	54	12	1.9	43	*	183			3.7	
251a		1086	285	54	34	1.6	360	225					2

* : not containing

Rozhdestvensky Aquifer

No	pH	Solid residue	Cation (mg/liter)				Anion (mg/liter)					Hardness (mg equivalent)	O_2 (mg/liter)
			Na + K	Ca	Mg	Fe	Cl	SO_4	HCO_3	NO_2	No_3		
1	7.8	1054	260	96	41	0.8	235	393	49	0	0	8.2	1.6
2	7.0	1036	131	65	46	0.9	213	188	366	2	240	9.6	1.4
3	7.2	1001	120	128	41	2.4	209	217	286	0.01	0.03	9.25	1.2
4	7.6	1081	155	120	47	1.8	224	270	220	0.05	3	8.25	1.6
6	7.7	1054	192	95	33	*	169	247	317	*	*	7.5	*
7	7.7	1382	308	88	35	*	172	329	451	*	*	7.3	*
8	7.5	1029	180	95	34	*	164	254	311	*	*	11.1	*
9	8.3	1299	177	130	76	*	317	240	360	*	*	12.8	*

* : not containing

Nurinsky Aquifer

No	pH	Solid residue	Cation (mg/liter)				Anion (mg/liter)					Hardness (mg equivalent)	O_2 (mg/liter)
			Na + K	Ca	Mg	Fe	Cl	SO_4	HCO_3	NO_2	No_3		
1	7.6	1060	129	94	60	0	158	280	0	0	8	9.6	0.3
2	7.7	952	113	68	52	0	128	112	0	0	7	7.7	
3	7.4	844	234	96	42	0.5	42	248	366			8.2	2.23
4	8.0	313	30	56	12	0	7	35	244	0		3.8	
5	7.6	723	75	70	39	0	37	101	0	0	0	6.7	
6	7.4	367	0	118	10	0.9	139	88	0	0	6	6.7	
7	7.6	399	0	50	41	1.9	40	80	0	0	0	5.86	*
8	7.8	582	43	72	4	0	18	49	0	0	8	5.6	*
9	7.6	587	43	76	24	0	28	45	0	4	7	6.1	*
10	8.0	347	*	76	47	0.4	106	72	*	0	0	7.7	1.76
12	7.8	1404	*	200	56	1.4	235	144	*	0	0	13.9	1.3
13	7.8	288	*	28	62	1.6	31	91	268	0	0	6	2.5
17	7.4	1544	*	190	63	2	152	588	*	0	0	14.7	2.4

* : not containing

FIGURE

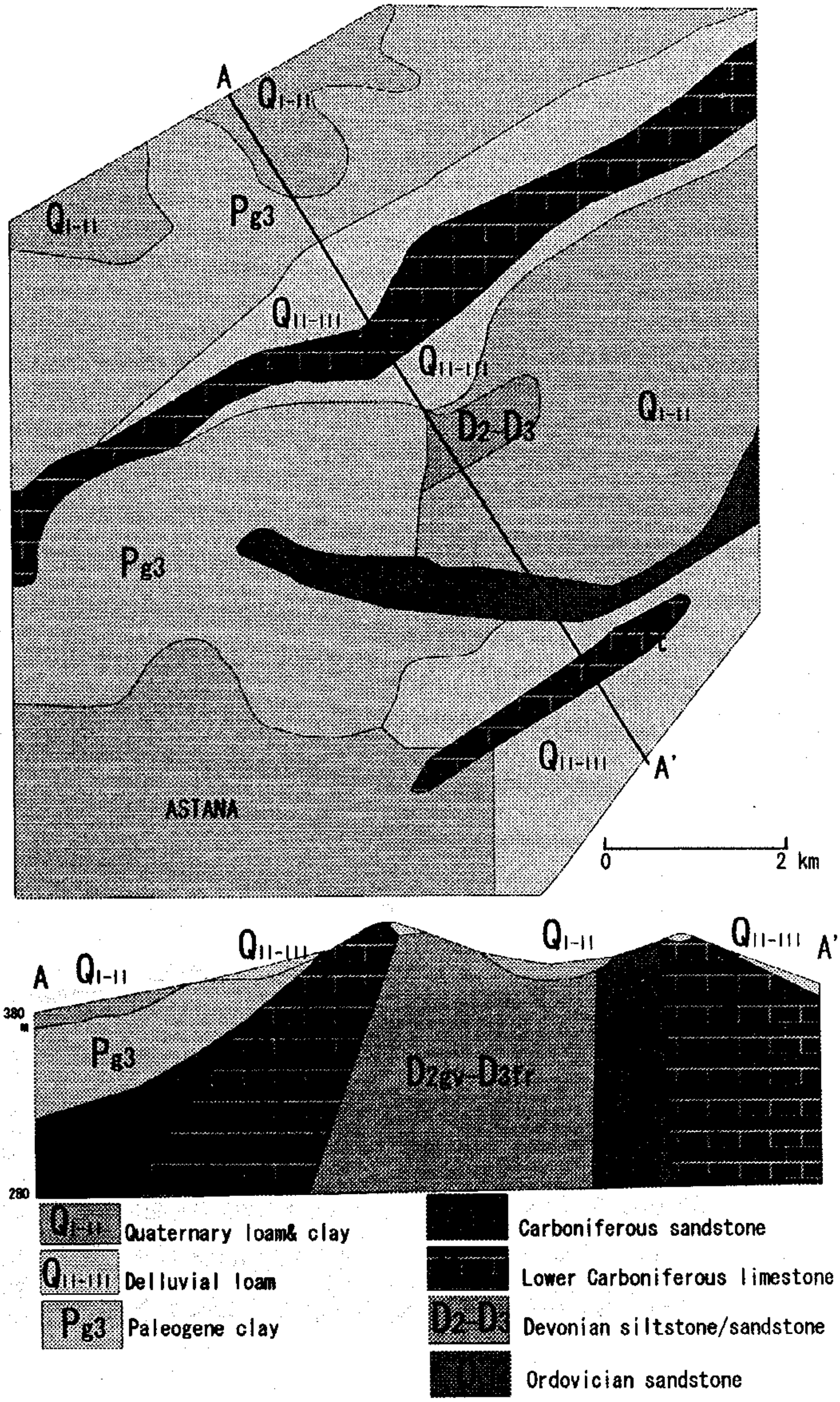

Figure D.1.1 Koyandinsky and Northeastern Sub-aquifer of Akmolinsky Aquifer

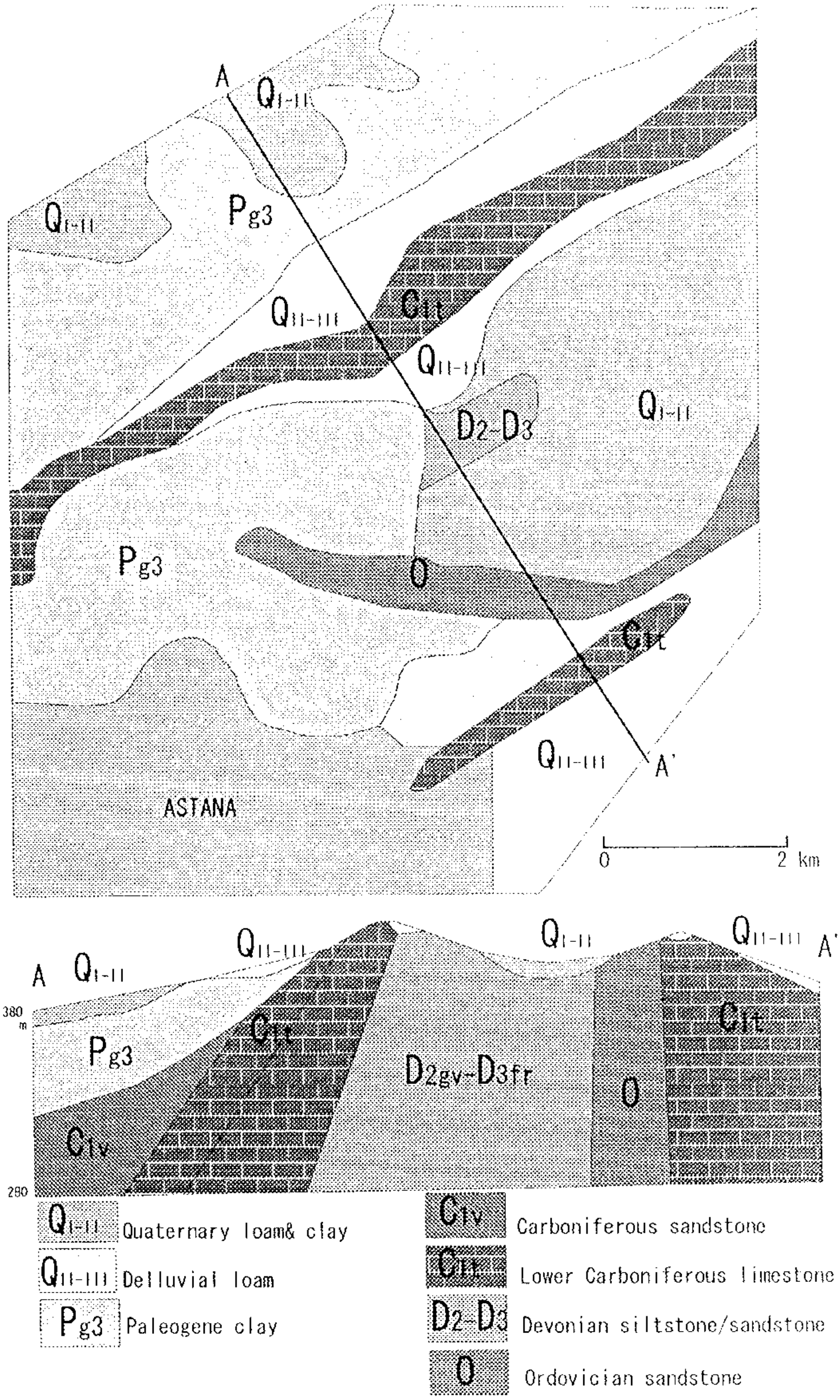

Figure D.1.1 Koyandinsky and Northeastern Sub-aquifer of Akmolinsky Aquifer

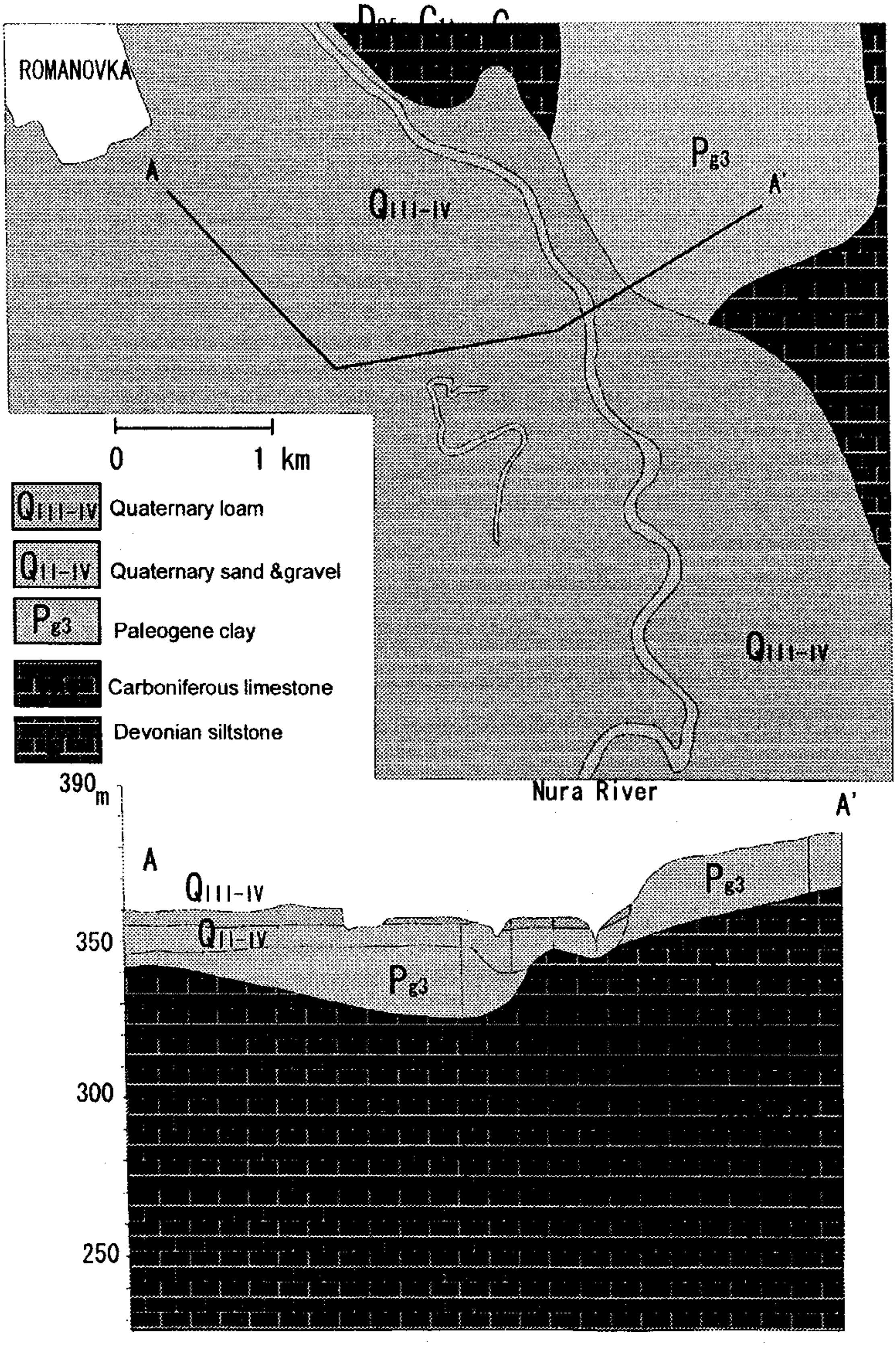

Figure D.1.2 Upper Sub-aquifer of Rozhdestvensky Aquifer

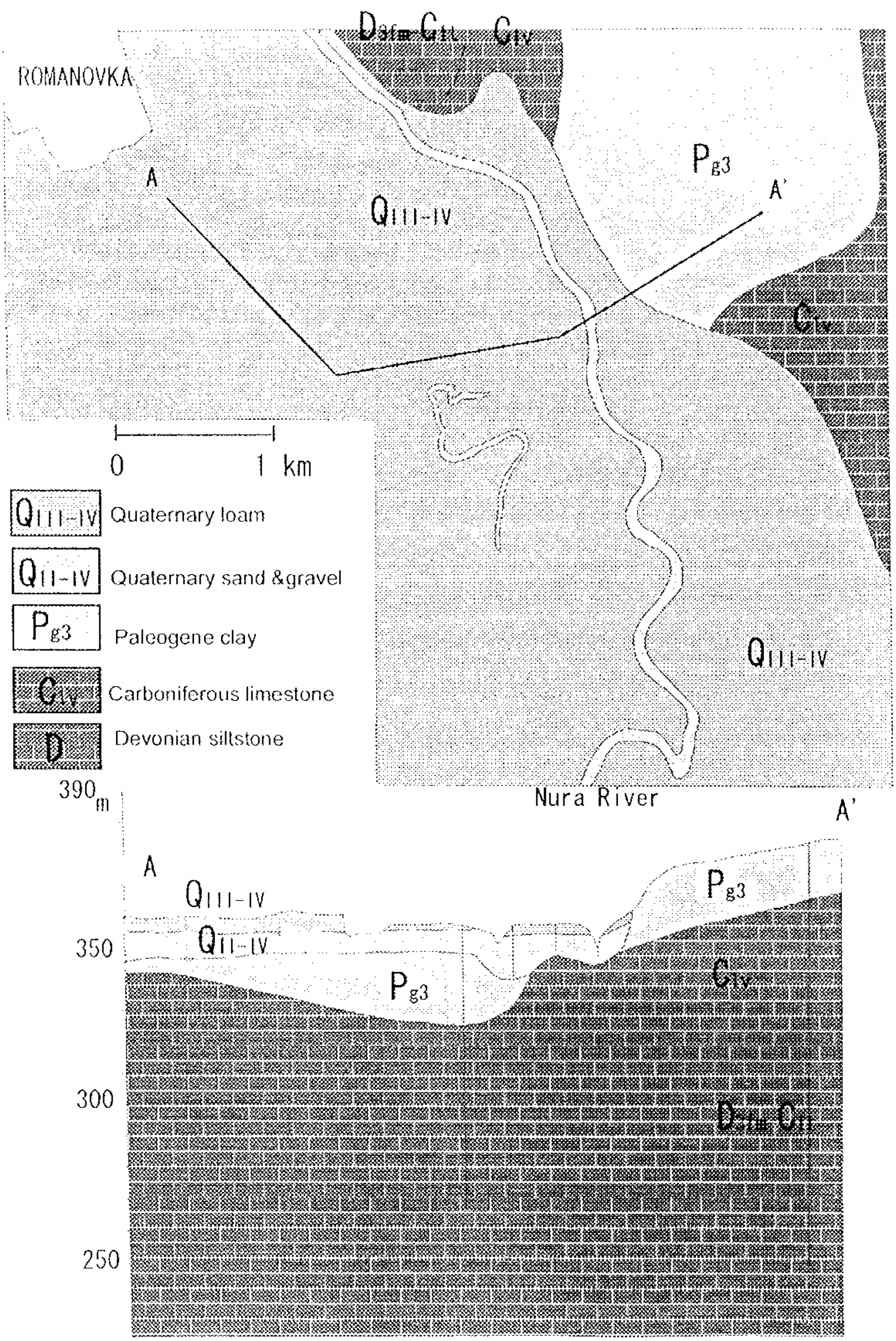

Figure D.1.2 Upper Sub-aquifer of Rozhdestvensky Aquifer

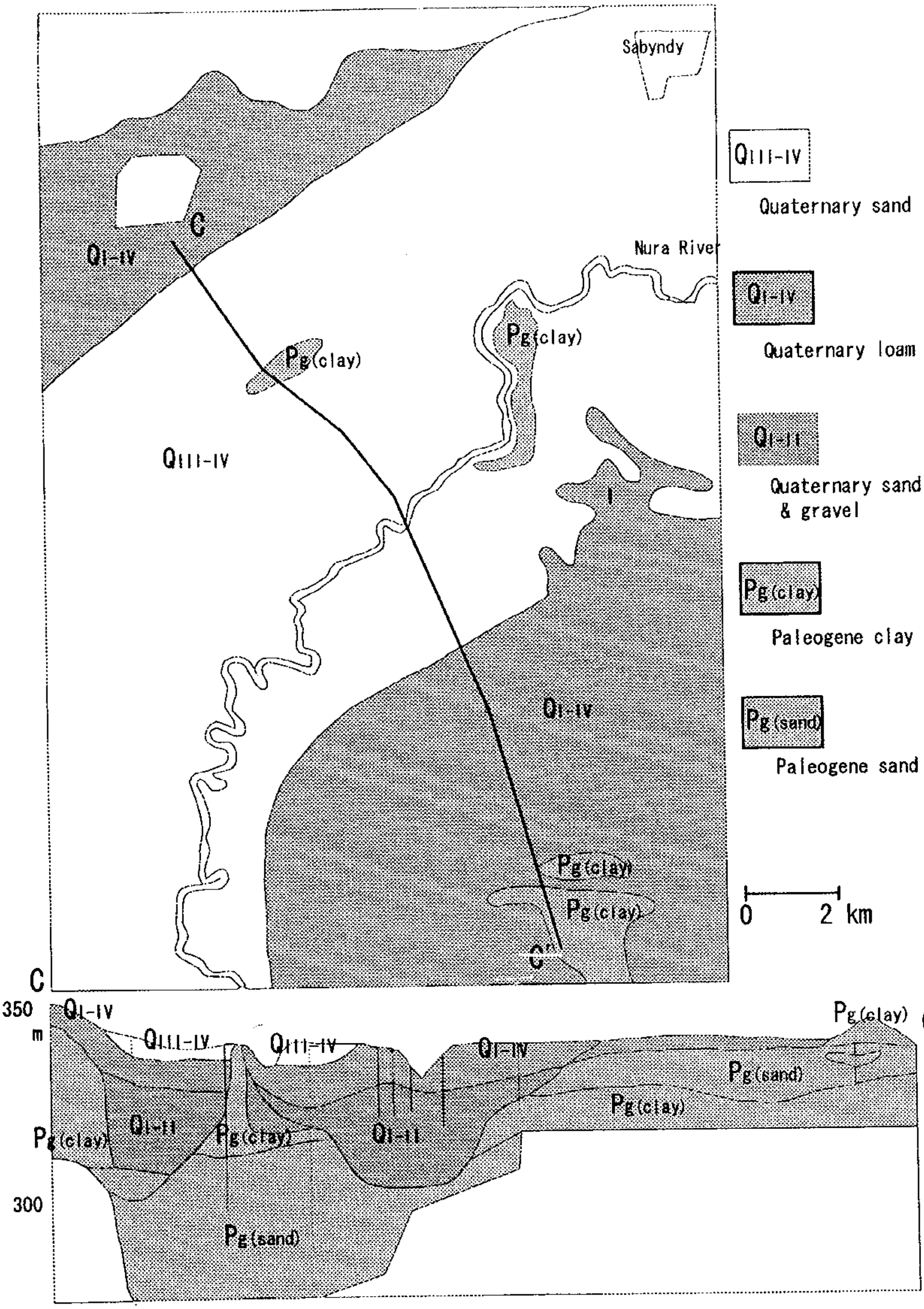

Figure D.1.3 Nurinsky Aquifer

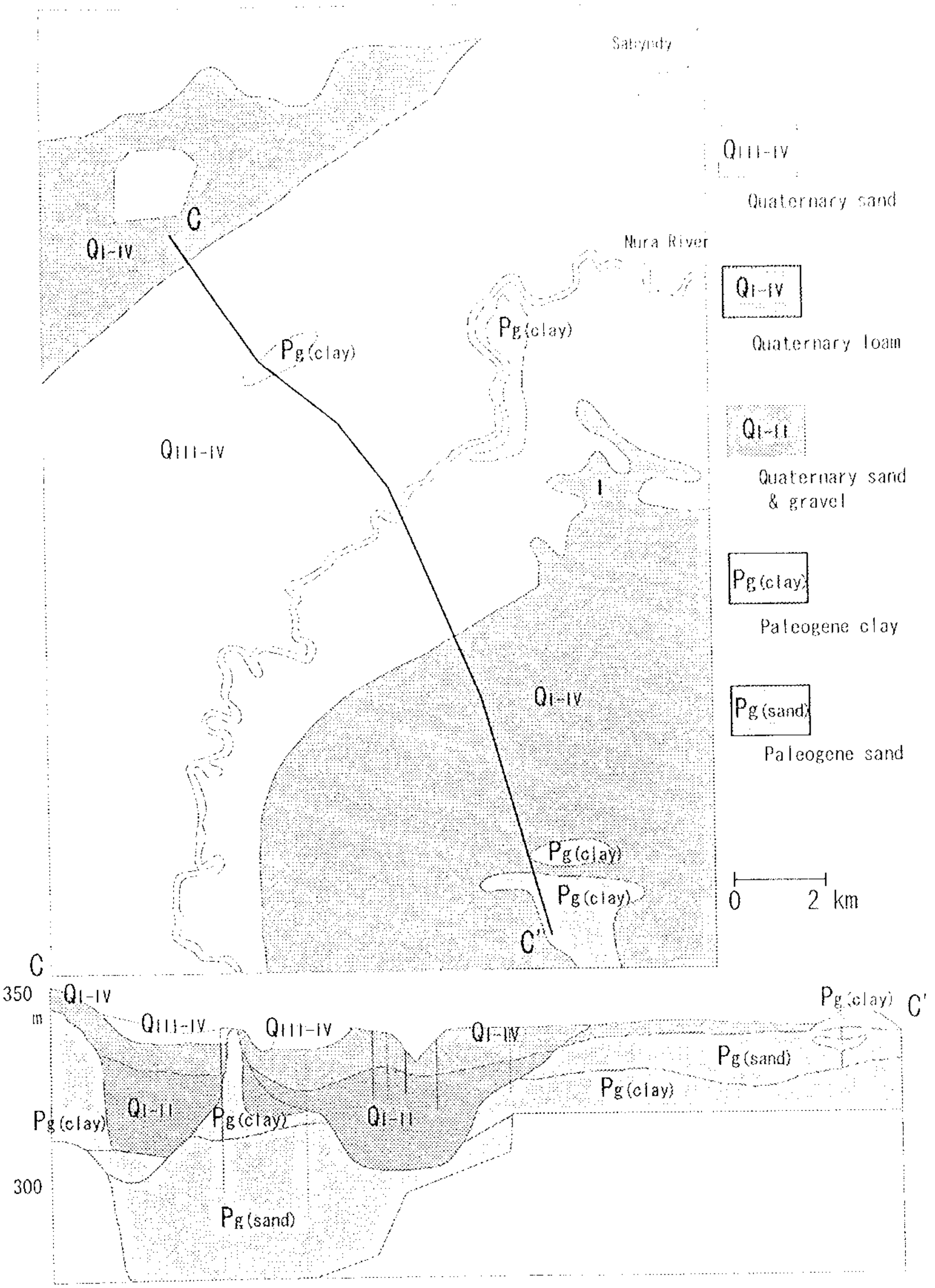

Figure D.1.3 Nurinsky Aquifer