OFFICE OF THE CHIEF ENGINEER GANGA BASIN REA (M.P.)

(Email id : cegangabasinrewa@gmail.com)

Memo No. 2512 /G/W/MP/ 1-48 of 22 Rewa, Date 19-4-22

To,

The Project Head
Dhirauli Coal Mine (The "Block")
M/s Stratatech Mineral Resources Pvt.Ltd.(SMRPL)
Tehsil-Saral District-Singrauli (M.P.)

Sub- No Objection certificate (NOC) and Permission for diversion of Hurdul Nalla for Dhirauli Coal Block which is an Open cast cum Underground mine of 6.5MTPA (5 MTPA Open Cast & 1.5 MTPA Underground) in Mine Lease Area of 2672 Ha held by M/s Stratatech Mineral Resources Private Limited (SMRPL) located at village Dhirauli, Phatpani, sirswah, Amdand, Jhalari, Amraikhoh, Basiberdah and Belwar, Tehsil-Sarai, District-Singrauli, Madhya Pradesh

Ref.- 1. Executive Engineer Water Resources Division No 2 Singrauli letter No.374/W/2022 singrauli Dated 09/02/2022
2. Your letter No SMRPL/HG/2022/79 Date 03.01.2022

With Reference to above cited subject, there is a Proposal to divert primary streamlet flow of Hurdul Nalla and surface run off water along periphery of mine lease boundary through construction of Catch drain. The peak flood discharge of Hurdul watershed i 702m3/s and the proposed diversion of Hurdul Nalla trench will be having a length of 6900 meters. The average hydraulic gradient of the diverted trench will be 1:100 and the garland drain/catch drain will be constructed in trapezoid shape with dimension of 1.5H:1 side length and floor width of 4m,3 meters water depth and 2m free board.

Based on the above technicaljustification, the Detailed Project Report (DPR) is approved and subsequently No objection certificate (NOC) & Permission/Approval has been issued for DIVERSION OF HURDUL NALLA for Dhirauli Coal Mine (The "Block") with following condition:

1. Diversion of Hurdul Nalla will be carried out by M/s SMRPL under supervision of office of the Chief Engineer, Ganga Basin, Rewa, Madhya Pradesh.
2. During monsoon period surface runoff should pass through sedimentation tank to arrest debris and Total suspended solids (TSS) before water is discharged into Hurdul Nalla.
3. During Non-monsoon period mine seepagewater should be treated to the extent of BIS standard for drinking water (IS10500-2012) before discharging into Hurdul Nalla.
4. All expenditure on account of construction of catch drain will be borne by Company.
5. The land acquisition for construction of catch drain belonging to either Govt. or Private will be responsibility of Company.
6. Permission from forest department and other departments will be responsibility of company.

Encl-One Copy of DPR

(C. M. Tripathi) 19.4.2022
Chief Engineer
Ganga Basin Rewa (M.P.)

End No 2513 /G/W/MP/ 1-48 of 22 Rewa Dated 19.4.22

Copy forwarded to :

Executive Engineer Water Resources Division No.2 Singrauli (M.P.) for information.

Encl-Nil.

(C. M. Tripathi) 19.4.2022
Chief Engineer
Ganga Basin Rewa (M.P.)

REPORT ON HYDROLOGY

For

Dhirauli Coal Mine (The "Block")

Dist Singrauli, Madhya Pradesh.

Project Proponent

M/s. Stratatech Mineral Resources Private Limited (SMRPL)

Prepared by

Nawal Kishor Prasad

Accredited Groundwater Professional CGWA
Accredited Functional Area Expert (Ground water & Hydrology) NABET

On the behalf of

SRUSHTI SEVA PRIVATE LIMITED

"Bilvadal" 8th, Janta Layout, Deendayal Nagar,
Nagpur – 440022 (Maharashtra)
Phone: 0712-2971968
Email: srspl15@gmail.com , srushtisewa@yahoo.com

December 2021

EXECUTIVE SUMMARY

The need for Hurdul Nala diversion for external surface runoff water from northern boundary of mine is required for conservation of nonrenewable coal resources. The nala diversion will also require avoiding mine inundation from peak flood runoff.
The Hydrological study for estimation of peak flood runoff for Hurdul nala watershed inclusive micro watershed of external area of mine has been also studied.

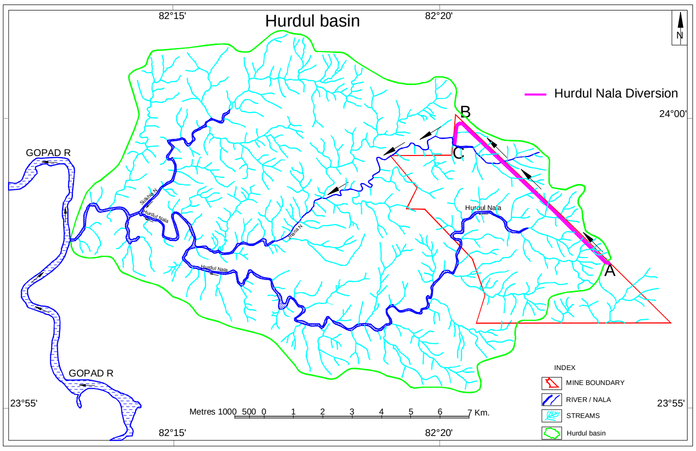
The Hydrological study concludes that peak flood runoff of Hurdul watershed (134 km2) is 702m^3/sec whereas, for external watershed it is 35m^3/sec which is 5% of peak flood of Hurdul watershed. The design storm flood runoff considering 2.5 times safety factor amounts to 88m^3/sec. The nala diversion trench has been designed using manning's equation. The dimension of trench will be as under.

Sr no.	Details	Data/Value	Sr no.	Details	Data/Value
1	Length of Diverted nala trench	6900 m	9	Length of Diverted nala trench	19 m
2	Width of Diverted nala trench	45 m	10	Length of berm (Embankment)	19 m
3	Start point of Diverted nala trench	555 m RL	11	Extra length	7 m
4	End point of Diverted nala trench	484 m RL	12	Total length	45 m
5	General slope of Diverted nala trench	1:100	13	Height of berm	5 m above trench
6	Width of Diverted nala trench	4 m	14	Top width of berm	4 m
7	Depth of water	3 m	15	Both side slope of Diverted nala trench and berm	1.5 H:1
8	Free board	2 m			

The summarized cost estimate for nala diversion trench along northern boundary will be as under

SUMMARY for Water Management at Dhirauli			
Sheet no.	**Details**	**No**	**Amount (Rs)**
1	Site Leveling - Surface Excavation	1	244047848.00
2	Site Leveling - Surface Filling	1	20014200.00
3	Nallah Diversion Trench	1	145288470.00
	G Total		409350518.00
Rupees Fourty Crore Ninety Three Lakhs Fifty Thousand Five Hundred & Eighteen Only			

The layout plan for nala diversion trench is given below



INDEX

TABLE

FIGURE

1.0 INTRODUCTION:

The M/s. Stratatech Mineral Resources Private Limited (SMRPL) allotted a coal mines vide Order no NA-104/7/2020-NA dated 03.03.2021 by Ministry of Coal, Govt. of India. The Particular of block is given as under.

Name of Coal Mine	Dhirauli
Coal Field	Singrauli Coalfield
Latitude	23° 56' 07" N – 24° 03' 04" N (Provisional)
Longitude	82° 19' 04" E – 82° 24' 21" E (Provisional)
Villages	Dhirauli, Suliyari, Phatani, Beri-Berdaha, Majhauli Path, Belwar
Tehsil/ Taluka	Singrauli
District	Singrauli
State	Madhya Pradesh

The location map is given in **Figure 1.1.**

M/s. SMRPL has issued letter of intent no. SMRPL/HO/DH/20—21/001 dated 04.08.2021 and subsequent So. No. 8130001262 with following scope of work and deliverables to M/s. Srushti Seva Private Limited, Nagpur

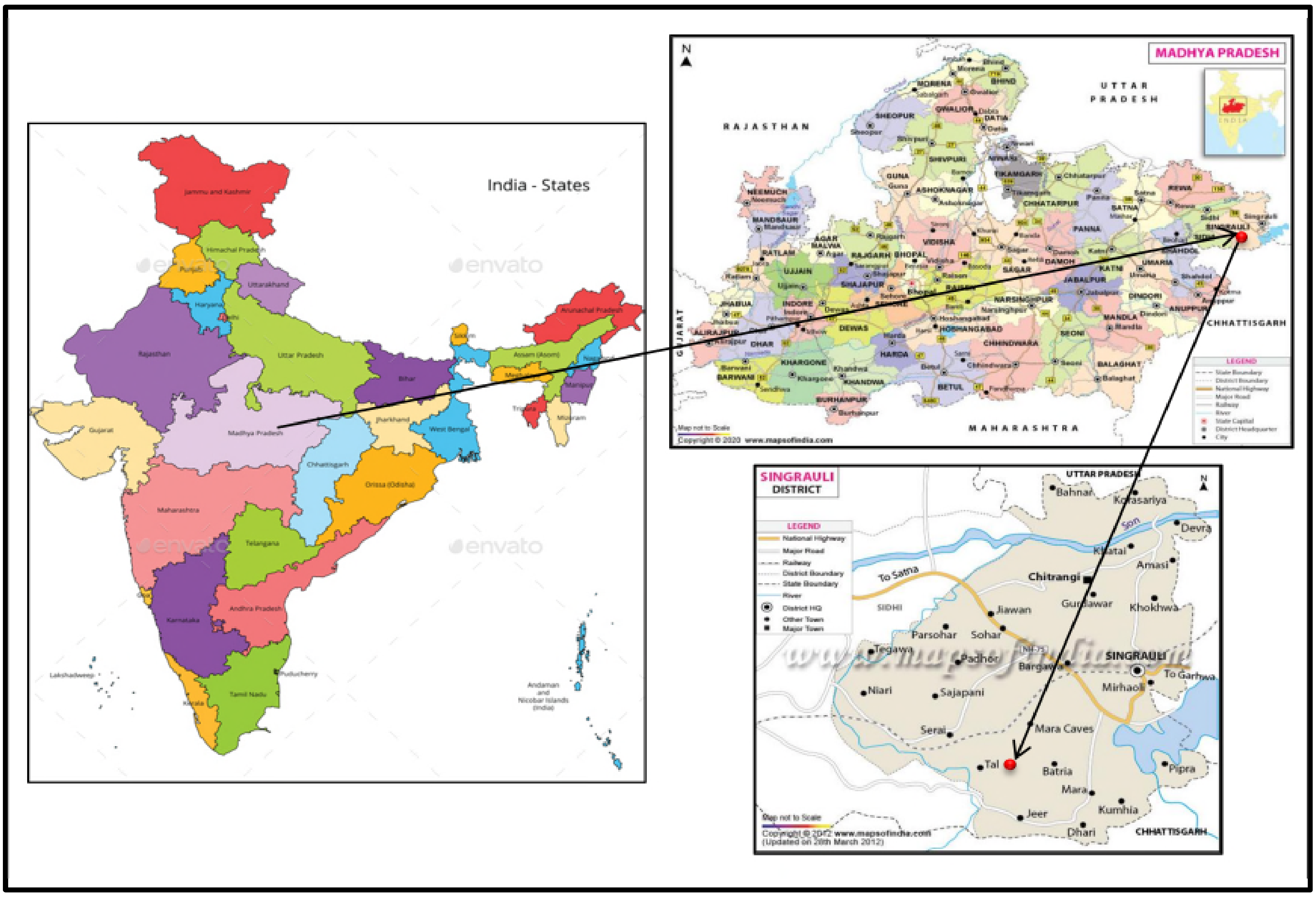


Figure 1.1: Location Map

1.1 Scope of Work:

1. To assess the cumulative impact of diversion of Hurdul stream
2. Study of availability of water in Hurdul i.e., perennial,/seasonal
3. Overall impact of nala diversion and its contribution to other big streams i.e., Gopad River etc.
4. Impact on livelihood support in its downstream and provisioning of alternatives in case of diversion
5. Effect on Aquatic Ecology (if any) and mitigation measures fir the same
6. Study of existing aquatic environment and its management considering the diversion of Hurdul nala
7. Hydrology assessment of the study area
8. Rationality of nala diversion in terms of coal conservation and stream restoration
9. To design the suitable nala profile proposed for diversion in line with State and Central guidelines based on contour survey and geotechnical parameters
10. Assessment of impact and diversion of nala considering minimum impact of aquatic life and environment
11. Impact assessment report of nala Diversion and design of nala in line with State and Central Government guidelines
12. Issue for construction drawings including longitudinal and cross sections (100 m interval) for proposed nala Diversion and embankment
13. Providing design calculations, technical specifications and bill of quantities (+/- 10%) for proposed nala diversion and embankment
14. Presentation to relevant authority whenever required

Deliverables:

1. Impact Assessment Report of nala Diversion and design of nala in line with State and Central Government guidelines
2. Issue for construction drawings including longitudinal and cross sections (100 m interval) for proposed nala diversion and embankment
3. Providing design calculations, technical specifications and bill of quantities (+/- 10%) for proposed nala diversion and embankment
4. Comments from WRD / Irrigation Department as per approved MOM

2.0 GENERAL ENVIRONMENTAL SETTING:

2.1 Location:

The Dhirauli Coal Block boundary coordinates in WGS-84 datum as per CMPDI is as follows in **Table 2.1.** The area is part of Toposheet no 64 I/5 (1:50000).

Table 2.1: List of Coordinal Points

Points	Northing	Easting
1	23° 56' 07"	82° 19' 04"
2	23° 56' 07"	82° 24' 21"
3	23° 03' 04"	82° 24' 21"
4	23° 03 04"	82° 19' 04"

2.2 Communication:

Waidhan – Sidhi State Highway via Bargawan traverses 20 km north of the block. A metalled road from Parsona to Mara is located further east of the block. An un-metalled road branching out of this at Rajmelan culuminates at Sarai. From this road to the west of River Mahan, a north – south running road leads to Langadda via Bhalyatola, Suliyari & Jhairi. The block is also accessible by an all-weather metalled road from Singrauli as well as from Waidhan. The distance of Sarai-Gram, the nearest major railway station on Choan-Singruali-Katni line of central railway is about 18 km from the block. The nearest Airport is Varanasi which is at a distance of about 250 km from Waidhan. Shakti Nagar is an important industrial town in the vicinity of Singrauli and Waidhan townships. The other very important industrial township and railway station Renukoot is at a distance of 70 km from Waidhan on Chopan-Garwah Road section of eastern railway.

2.3 Topography & Drainage density:

Southern part of Dhirauli block is characterized by almost plain topography, while, north-eastern and south-central part are highly undulating and have rugged topography as evident from the topographical plan. The north-eastern and south central part of the block have forest cover and is occupied by hillocks of elevation up to a maximum of 638 m above MSL. In general elevation of ground varies from 633 m to 456 m a msl. The lowest point is Nala bed of Hurdul nala at exit from mine area. The GIS tool has been used to prepare Digital Elevation Model (DEM) of the mine and adjoining area and it is depicted in **Figure 2.1**.

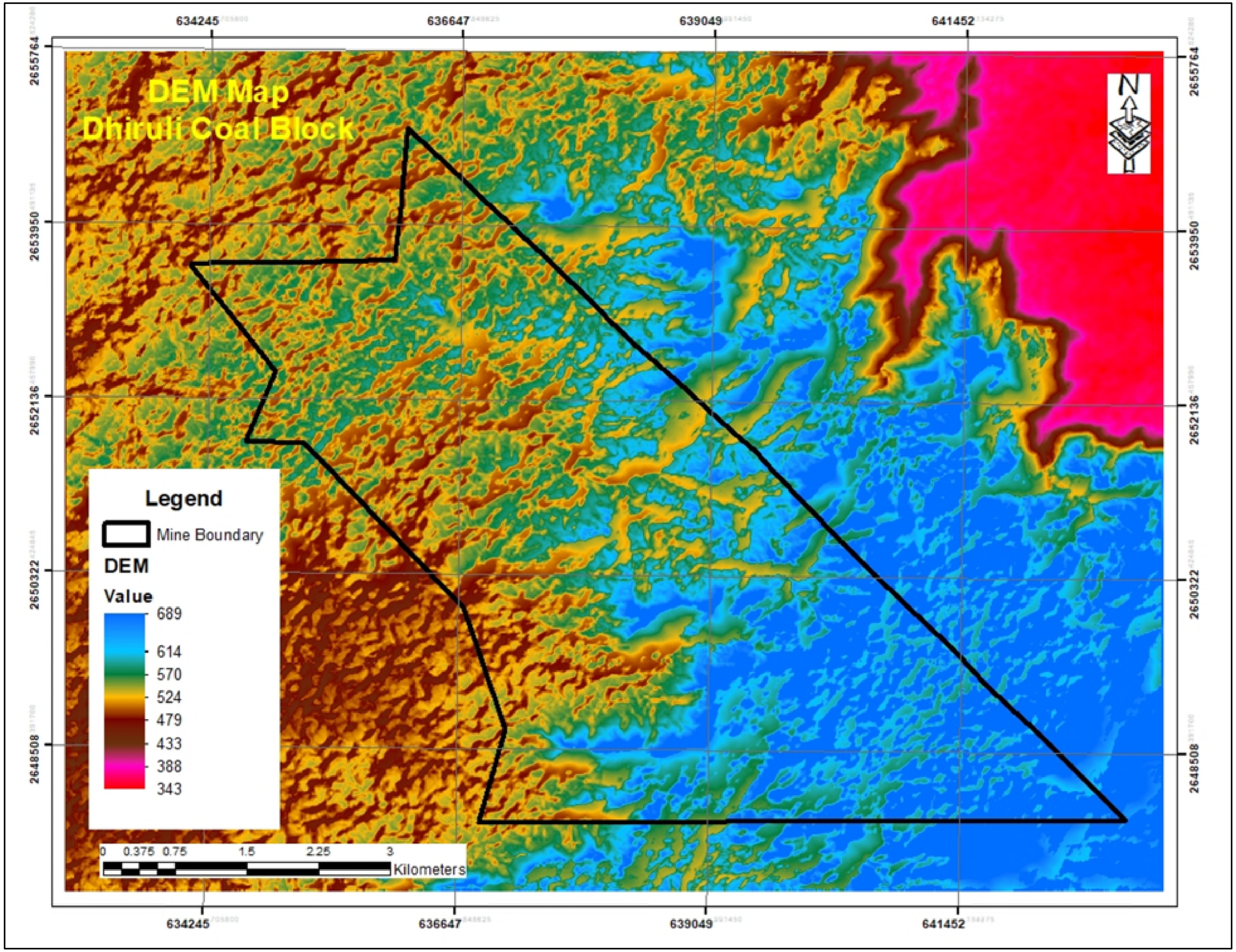


Figure 2.1: Digital Elevation Model (DEM)

Drainage density of the block is mainly controlled by westerly flowing Hurdul Nala which traverses the block and passes almost through central part of the block. Many small seasonal nallas originating from elevated topography from north eastern and south central part of the block which Diverted nala trenchs its water into Hurdul Nala. The minor nallas and tributaries present in the block shown dendritic to sub-dendritic Drainage density pattern. The location on toposheet is given in **Figure 2.2.**

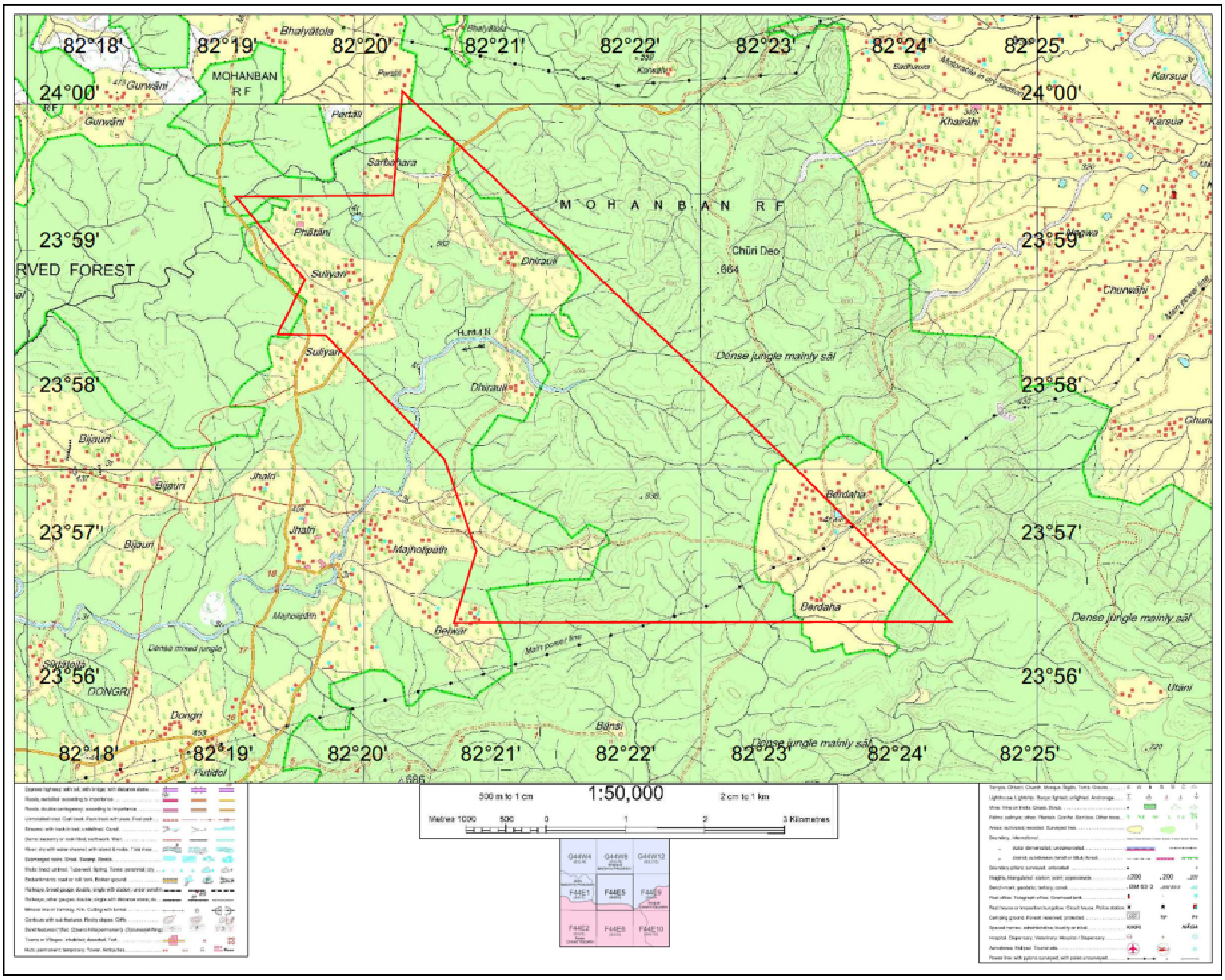


Figure 2.2: Location on Toposheet

3.0 GEOLOGY & HYDROGEOLOGY:

3.1 Geology:

Singrauli coalfield forms the northern extremity of Son-Mahanadi master Gondwana basin. The northern limit of the Singrauli coal field is defined by a major east west trending northern boundary fault, which is parallel to the Narmada-Son lineament. High standing Mahadeva hills are defining the southern boundary. Talchir beds rest unconformable over Precambrian rocks and the Precambrian themselves, are forming the eastern boundary whereas the western boundary is formed by the contact of Precambrian and supra Barakar sediments. The generalized stratigraphic succession (after Lascar, et.al 1977 and Raja Rao 1983) is given below**.**

Stratigraphy:

Thus based on both the surface and sub-surface data available, the following stratigraphic succession is given in **Table 3.1.**

Table 3.1: Stratigraphic succession of Singrauli Coalfield

Age	Group	Formation	Lithology
Cretaceous		Intrusives	Dolerite dykes & sills
Upper Triassic (?)	Upper Gondwana	Mahadeva	Coarse grains, ferruginous sandstone with bands of shale, clay and conglomerates.
Lower Triassic	Lower Gondwana	Panchet (?)	White, greenish white and pink micaceous, medium to coarse grianed sandstone with red beds, greenish brown silty shales and conglomerates
Upper Permian		Raniganj (215-403 m)	Fine grained sandstones and shales with coal seams including 134 m thick Jhingurdah seam
Midle Permian		Barren Measures (125-300 m)	Very coarse grained, ferruginous, sandstones, green clays & shales
Lower Permian		Barakar (325-600 m)	Medium to coarse grained, sandstoes, shales, clays and coal seams
Upper Carboniferous to Lower Permian		Talchir (75 – 130 m)	Tillite, sandstone, siltstones, needle shales etc.
--------------------------- Unconformity ---------------------------			
Precambrian		Precambrian	Phyllites, quartzites, schists and gneisses

(Source: Mine Plan given by proponent)

3.1.1 Local Geology:

3.1.1.1 Geological Structures:

The Dhirauli block is traversed by 11 normal gravity faults designated as F1 – F1 to F11 – F11. There are two sets of faults – one trending NW-SE and the other trending NE-SW. The magnitude of these faults varies from 5 m to 85 m within the block. The faults have been deciphered based on the floor level difference observed on either side of the fault planes and on the basis of borehole intersections. It is pertinent to mention here that, the numbers of minor slips are also observed in boreholes causing of 11 faults interpreted 10 faults are of low magnitude having thrown between 5 m to 35 m, except fault F9 – F9 which is having a maximum 85 m of throw.

Strike and Dip:

In general, the strike varies from NE-SW in the entire area of the block to almost E-W in the southern part of the block with gentle dip of 2° to 4° north – easterly to north and south – westerly to south at places.

Reserve: The following coal reserve have been estimated in mine plan. The geological and mineable reserve is given in **Table 3.2.**

Table 3.2: Geological and Mineable Reserve

Sr. No.	Type of Description	Reserve (Million ton)
1	Gross Geological Reserve	620.013
2	Net Geological Reserve	558.011
3	Mineable Reserve	313.79

(Source: Mine Plan given by proponent)

3.2 Hydrogeology:

3.2.1 Hydrogeological Setting:

Singrauli Coal Field is located in Sone Drainage density basin. Dhirauli Coal Block form a part of Singrauli main Coal Block. The top formation is Raniganj Sandstone/shale of lower Barakar. The Raniganj formation form aquifer above coal seam. Hydrogeological Map is given in **Figure 3.1.**

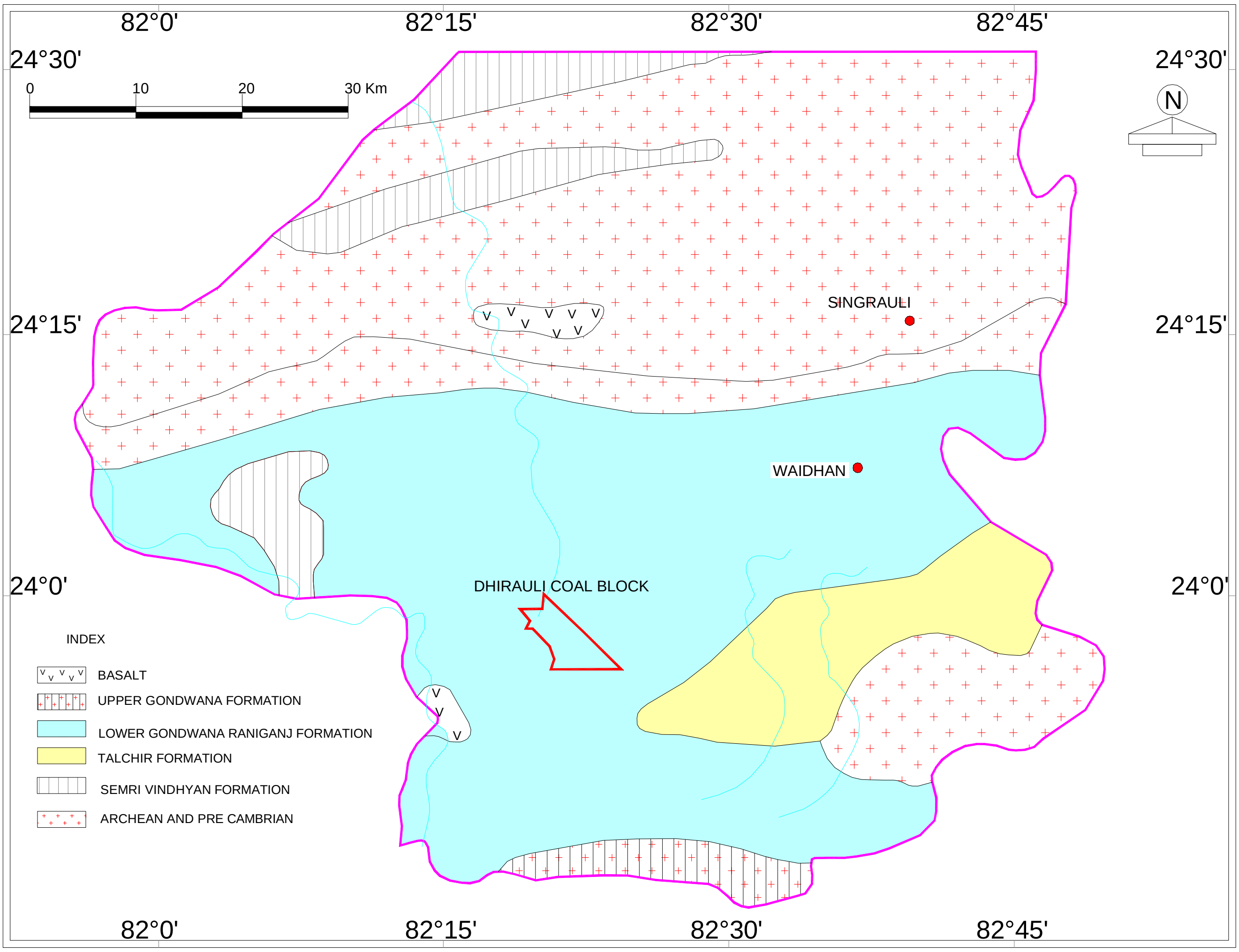


Figure 3.1: Hydrogeology Map of Dhirauli Coal Field

(Source: District Survey Report)

3.2.2 Mode of Occurrence:

Groundwater occurs under both unconfined and semi-confined to confined conditions. Unconfined conditions prevail where the aquifers are uncovered and consist of relatively permeable formations such as top sandy soil or loose sandstones. The deeper stratified aquifer system is of semi-confined nature due to the various leaky aquitards within the aquifer. Within the lower Barakars above the coal seam, there is a band of carb-shale/coal which seems to be extensive in nature and uniform in spread throughout most of the block area. The aquifer below the extensive carb-shale band may be of confined condition because of the overlying impermeable shale and coal seam. Coal seam I acting as aquiclude.

3.2.3 Generalized Hydrogeological Model:

Generalized hydrogeological model of the study area is prepared by using open cast and underground coal mining characteristics and depth according to Pre-Feasibility Report given by proponent. Based on lithology it is informed that there are one semi confined and eight confined aquifer systems and seven aquiclude and decipher in **Figure** 3.**2.**

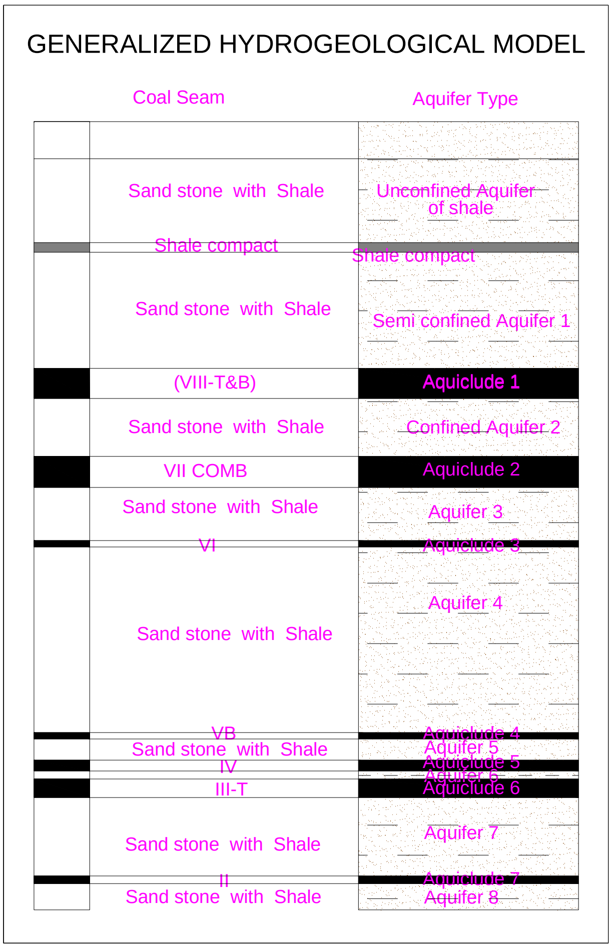


Figure 3.2: Generalized Hydrogeological Model

3.3 Depth to Water Level:

3.3.1 Depth to water level at Sarai Village Nearest Hydrographic station:

The ground water trend analysis for 10 years data has been analyzed. The CGWB National Hydrographic Station at Sarai Village located approximately 20 km distance from Dhirauli coal block, has been considered for ground water level trend analysis. The pre and post monsoon water level have been given in **Table 3.3** and the graphs of pre and post monsoon is plotted in **Figure 3.3 & 3.4** respectively.

Table 3.3: Pre Monsoon & Post Monsoon Water Level

Location- Sarai Village			
Sr no.	**Year**	**Pre monsoon**	**Post monsoon**
1	2011	6	2.64
2	2012	5.2	2.94
3	2013	5.9	2.3
4	2014	5.3	3.4
5	2015	5	2.8
6	2016	5.99	5.55
7	2017	7.25	7.17
8	2018	5	3
9	2019	5.8	3.6
10	2020	6	3.6

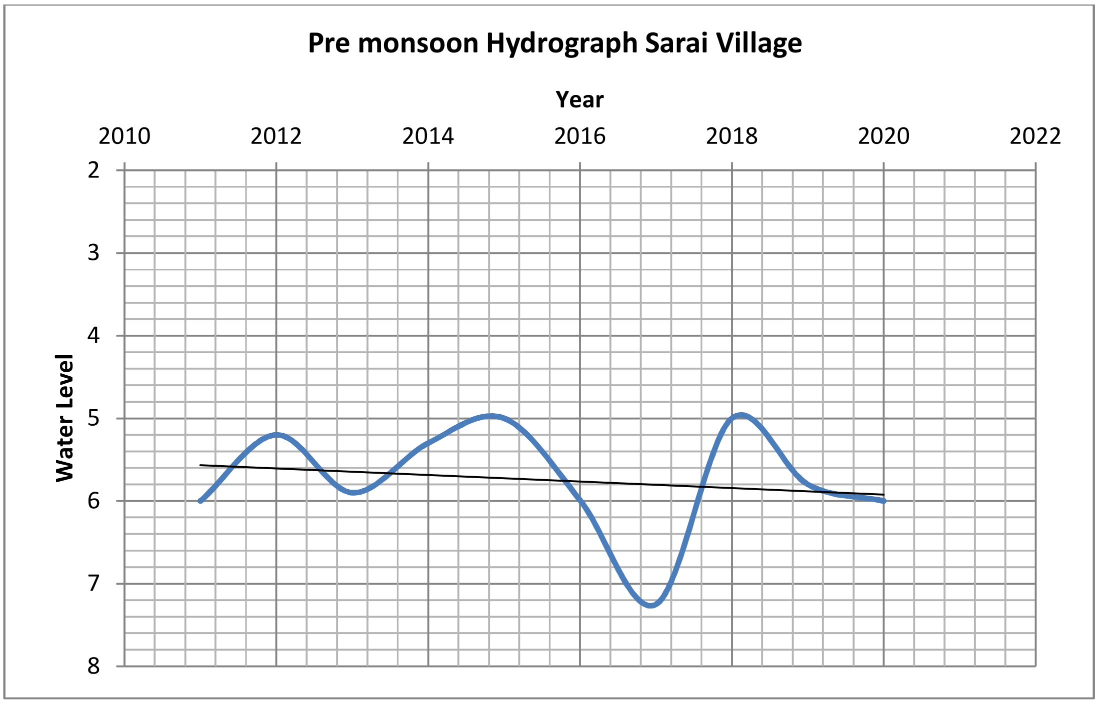


Figure 3.3: Hydrograph of Pre Monsoon

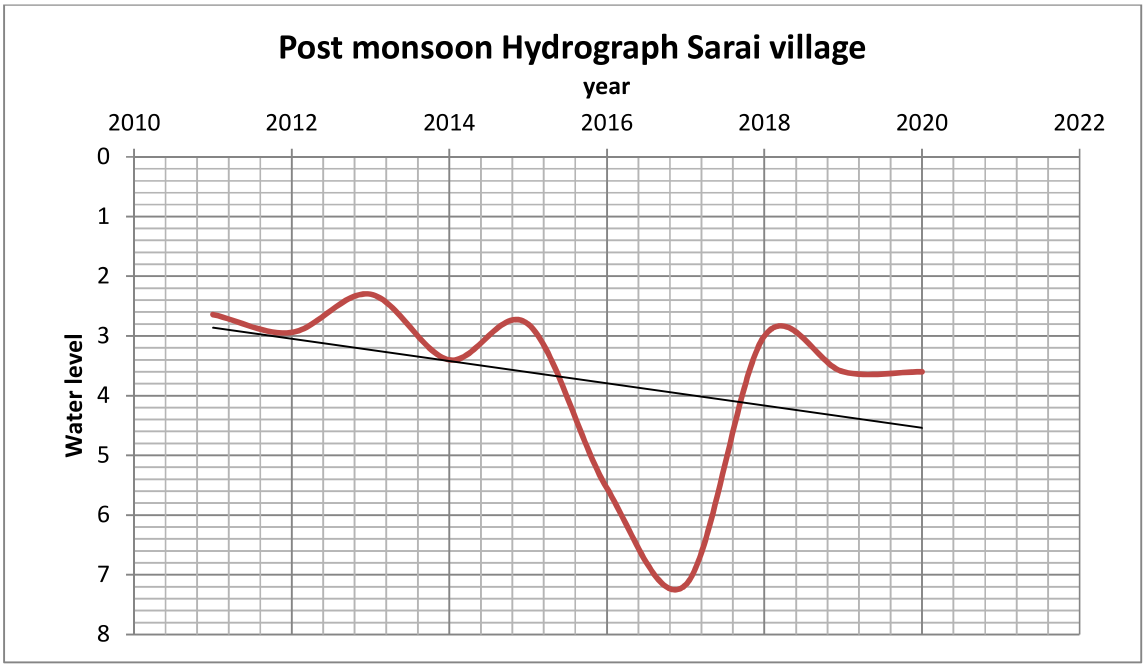


Figure 3.4: Hydrograph of Post Monsoon

Table 3.4: Trend Analysis of Ground water 10 years

Sr. No.	Pre and post monsoon	Trend water level 2010	Trend water level 2020	Year of Data	Trend fall or rise	Trend rise or decline	Remarks
		A	B		A-B/10		
1	Pre	5.6	5.9	10	0.3/10	-0.03	There is annual decline in water level
2	Post	2.8	4.5	10	1.7/10	-0.17	

The maximum pre and post monsoon water level reported to the tune of 7.25 m bgl. This is also declining trend.

3.3.2 Depth to water level at Dhirauli Coal Block:

Water level data from core zone area of Dhirauli Coal Block is given below.

Well no.	Village	Latitude	Longitude	Well Type	Total Depth (m)	Dia (m)	Static Water Level (m)		Fluctuation	Aquifer
							Pre - Monsoon	Post - Monsoon		
1	ML Area Dhirauli South	23^{c} 59′ 15′′	82^{o} 19′ 25′′	Dug well	15.24	3.66	13.1	5.9	7.2	Gondwana

(Source- Comprehensive Report on Groundwater Sept-2021)

Fluctuation in water level to the tune of 7.2 m. This may be due to location of well is in recharge zone of Hurdul Watershed commonly known as ridge area of basin.

Ground water recharges during Non-Mining:

The mine area and external area is 33 km^2. The annual fluctuation (A.F) is 4 m. The specific yield (Sy) is 3%. The annual dynamic recharge estimated as

Recharge = Area × AF×Sy

= $33\times10^6\times4\times0.03$

= 3.96 MCM/year

Ground water recharge by Rainfall infiltration method- Normal Rainfall

As per GEC CGWB the infiltration coefficient recommended 12%.

Recharge= Area× Monsoon rainfall× Rainfall infiltration coefficient

= $33\times 10^6\times 1.006\times 0.12$

= 3.98 MCM/year

Average ground water recharge = 3.97 MCM/year.

Ground Water Recharge during Mining:

Due to change in rainfall infiltration capacity of soil during mining ground water recharge increases. The infiltration coefficient increased by 11% as per UNDP study carried out in Indian Coal Field. Thus, the rainfall infiltration coefficient increases to 23%. The ground water recharge during mining period will be estimated as under

Ground water Recharge = $33\times10^6\times0.23\times1.006$ = 7.6 MCM/year

Net increase in ground water recharge due to mining = 3.63 MCM/year

7.6 MCM/year ground water will be discharged from mine into Drainage density in form of mine seepage in addition to mine seepage through deeper aquifer system. The non-monsoon stream flow into Hurdul Nala within mine Drainage density is estimated as under.

Non-monsoon mine seepage = 7.6×10^6 m^3/243 days

Daily flow into Hurdul Nala = $7.6\times10^6\div(243\times24\times3600)$

= 0.36 m^3/sec

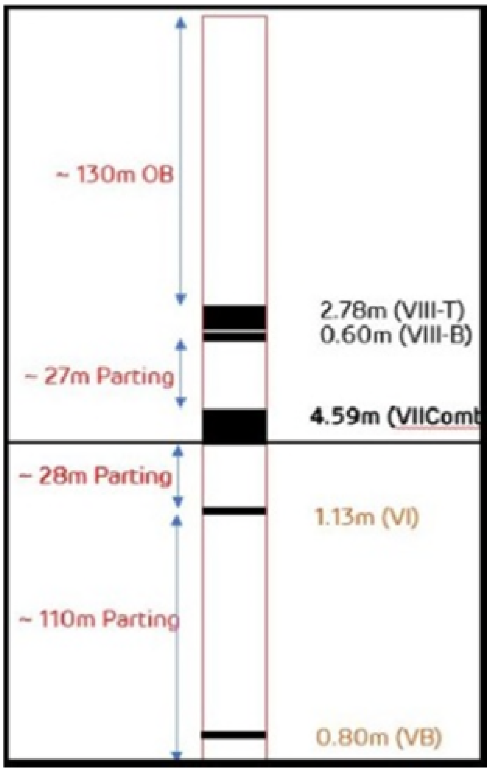
Additional Non Monsoon Stream Flow = 0.36 m^3/sec

4.0 MINING:

The Salient part of mine plan document is reproduced for ready reference.

4.1 Proposed Method of Mining:

Considering the geo-mining characteristics of the block and for conservation of resource, it is proposed to extract the coal reserves within the block using combination of open cast mining (up to Seam VII) and underground mining (below Seam VII to Seam II) method.



Opencast limit is planned up to Seam VII floor due to thick parting and thin coal seams below Seam VIII.

4.2 Opening Location:

The mine opening is planned from southwest corner of block (in – crop of seam VII) and further development is planned along strike of the seam.

A patch of 387.55 Ha in the south west corner is non-coal bearing (considering seams for opencast mining only) beyond in-crop of Seam – VII where it is proposed to have the external dump.

Non coal bearing area (beyond in crop of VII Seam) of approx. 21 Ha shall be utilized for mine facilities, additionally another patch of ~9 ha is proposed for underground infrastructure for second set of incline planned at north-west side of block.

4.3 Mining Scheme:

Based on the above geo-mining condition, Mining system has been worked out for achievement of rated capacity in shorter period i.e. low gestation period as well as reduction of Inter-mixing of coal with stone bands and starting of internal dumping as soon as sufficient de-coaled area is created. The top OB benches above mining mass would be worked in horizontal slicing method.

4.3.1 Bench Height:

1	For OBR (12 m^3 Hyd. Shovel)	10-12
2	Top soil / Intervening Parting (3-4.5 m^3 excavator)	3-6 m
3	Coal	as per thickness

4.3.2 Proposed Bench Width:

1	Working Bench Width for 12 m^3 Hyd. Shovel		20-30
2	Non-working Bench Width for 12 m^3 Hyd. Shovel		12-20 m
3	Width of the temporary transport ramp		20 m
4	Usual height of the Top soil / parting dump bench		12-15 m
5	Usual height of the Hard Rock dump bench		30 m
6	Bench Slope		
	a	OB Bench	70°
	b	Coal Bench	70°
	c	Dump Bench	37°
7	Overall (Ultimate) pit slope		37°

4.4 Sequence of Mining:

Dhirauli Coal Mine is planned from south-west corner of block (seam VII in crop). Due to high strip ratio and limited space of OB dumping coal evacuation is planned from advancing face and no permanent haulage road is planned for the block. The box cut is developed in such a manner so as to facilitate the proper Drainage density of water towards the sump. This would also facilitate extension of coal and OB bench for full development of mine. The mine will advance towards dip direction exposing the floor of Seam-VII. After creation of sufficient de-coaled area of about 100 m, internal backfilling of OB will be started in the 3rd year of mining operation. The coal production will start from the 1st year of mine operation and the target coal production of 5.00 MTY will be achieved in the 3rd year of mine operation.

The alignment of the face has been so planned as to facilitate the Drainage density of water. Entire quarry has been planned for OB dumping by leaving lag distance of 100 meter from advancing benches (northern side).

A surface retrieving conveyor will be installed along the center of block form 2nd year. Coal shall be transported from mine face to dump station by truck. Moveable dump station is planned which will be shifted at 5 year interval timeframe stage plans are given in **Figure 4.1.**

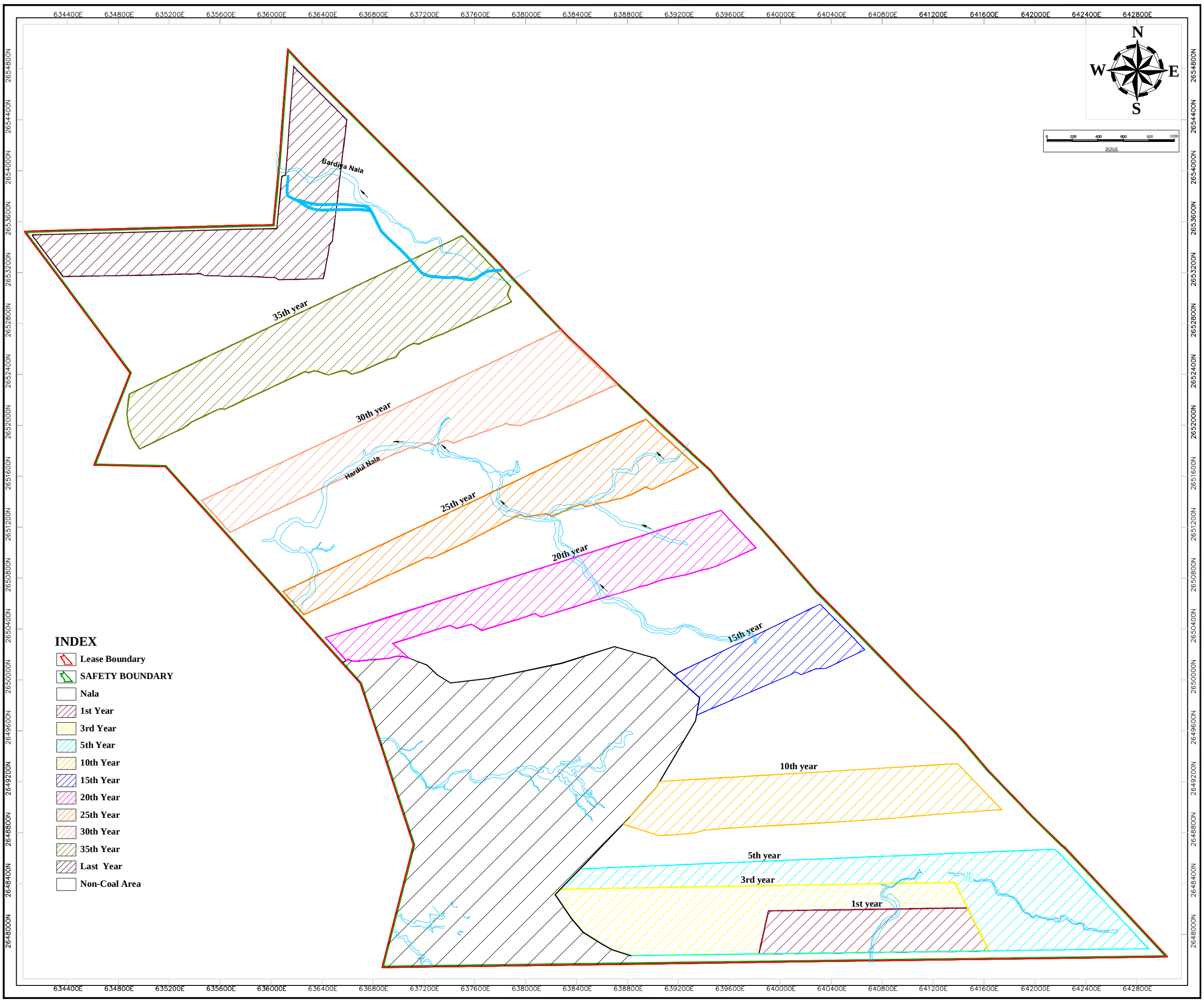


Figure 4.1: Stage Plans

4.5 Overburden Removal and OB Dumps:

The opencast mine is planned up to 280 m depth on the floor of seam-VII with overall average stripping ratio of 10.55 m3/te.

The total volume of OB has been estimated as 1963.55 Mcum. The OB removed during initial years will be placed beyond the in crop of the seam VII as external dump. The total volume of external dump has been the total volume of OB has been estimated as 1963.55 Mcum. The OB removed during initial years will be placed beyond the in crop of the seam VII as external dump. The total volume of external dump has been estimated as 259.01 Mm3. Rest of the OB will be placed as internal dumps. The total volume of internal OB, i.e. the volume which will be accommodated internally by backfilling has been estimated as 1704.54 Mm3.

The internal dumping will start when about 100 m internal space is available on quarry floor. By adopting the proposed sequence of mining, as the quarry advances, the amount of internal dump will increase as more space for the internal dumping is created.

It is proposed to start internal dumping from 3rd year of mine operation along with external dumping to optimize lead. As the gradient of the seam is flat, during working of the quarry substantial amount of OB can be accommodated as internal dump. After 18th year of mine operation, no external dumping will be required. Hence, OB will be accommodated as internal dump for rest of the mine life.

During 1st year, height of external dump will be kept at only 60 m above the ground level. During 3rd year, height of eastern external dump and eastern in-pit dump will be merged by maintaining 90m height above the ground level (RL of 600). At the end of 5th year height of internal dump will be 90m above ground level. At the end of mine life, internal dump will be at 60 above the ground level for some part. Solid Waste Management of Dhirauli coal Block is given below.

Year	External Dump		Internal Dump		Total OB	
	Progressive (Mcum)	Cumulative (Mcum)	Progressive (Mcum)	Cumulative (Mcum)	Progressive (Mcum)	Cumulative (Mcum)
Yr-1	16.35	16.35	-	-	16.35	16.35
Yr-2	28.12	44.47	-	-	28.12	44.47
Yr-3	19.36	63.83	13.94	13.94	33.30	77.77
Yr-4	12.39	76.22	20.76	34.70	33.15	110.92
Yr-5	11.64	87.86	21.53	56.23	33.17	144.09
Yr-6	10.5	98.36	24.30	80.53	34.80	178.89
Yr-7	11.34	109.70	24.66	105.19	36.00	214.89
Yr-8	11.55	121.25	25.70	130.89	37.25	252.14
Yr-9	11.97	133.22	26.33	157.22	38.30	290.44

Year	External Dump		Internal Dump		Total OB	
	Progressive (Mcum)	Cumulative (Mcum)	Progressive (Mcum)	Cumulative (Mcum)	Progressive (Mcum)	Cumulative (Mcum)
Yr-10	12.11	145.33	26.49	183.71	38.60	329.04
Yr-11	12.81	158.14	27.49	211.20	40.30	369.34
Yr-12	13.02	171.16	28.73	239.93	41.75	411.09
Yr-13	13.58	184.74	30.32	270.25	43.90	454.99
Yr-14	13.79	198.53	32.11	302.36	45.90	500.89
Yr-15	14.42	212.95	32.88	335.24	47.30	548.19
Yr-16	14.91	227.86	34.09	369.33	49.00	597.19
Yr-17	15.33	243.19	34.72	404.05	50.05	647.24
Yr-18	15.82	259.01	35.03	439.08	50.85	698.09
Yr-19	-	259.01	51.40	490.48	51.40	749.49
Yr-20	-	259.01	52.25	542.73	52.25	801.74
Yr-21	-	259.01	53.30	596.03	53.30	855.04
Yr-22	-	259.01	54.25	650.28	54.25	909.29
Yr-23	-	259.01	55.75	706.03	55.75	965.04
Yr-24	-	259.01	58.25	764.28	58.25	1023.29
Yr-25	-	259.01	60.75	825.03	60.75	1084.04
Yr-26	-	259.01	62.75	887.78	62.75	1146.79
Yr-27	-	259.01	64.00	951.78	64.00	1210.79
Yr-28	-	259.01	64.50	1016.28	64.50	1275.29
Yr-29	-	259.01	65.50	1081.78	65.50	1340.79
Yr-30	-	259.01	65.75	1147.53	65.75	1406.54
Yr-31	-	259.01	66.50	1214.03	66.50	1473.04
Yr-32	-	259.01	67.25	1281.28	67.25	1540.29
Yr-33	-	259.01	67.25	1348.53	67.25	1607.54
Yr-34	-	259.01	67.75	1416.28	67.75	1675.29
Yr-35	-	259.01	68.50	1484.78	68.50	1743.79
Yr-36	-	259.01	68.50	1553.28	68.50	1812.29
Yr-37	-	259.01	69.25	1622.53	69.25	1881.54
Yr-38	-	259.01	53.50	1676.03	53.50	1935.04
Yr-39	-	259.01	21.50	1697.53	21.50	1956.54
Yr-40	-	259.01	7.01	1704.54	7.01	1963.55
Total	259.01	259.01	1704.54	1704.54	1963.55	1963.55
	259.01		1704.54		1963.55	

4.6 Top Soil Management:

Top soil is proposed to be removed separately and dumped outside the quarry in a manner so as not to lose its fertility. The top soil would be spread over the reclaimed land, afterward. Top soil will be removed and dumped on the area shown on surface plan. Top soil will be stored for initial four years and during subsequent years it will be directly spread over the reclaimed area.

Top soil details:

1. Height of Topsoil dump : 3 meters
2. Year of Reclamation : after 5^{th} year of mine operation

Year	Top Soil (M cum)
1	0.80
2	0.90
3	0.50
4	0.40
5	0.30

(Source: Mine Plan given by proponent)

5.0 CLIMATIC WATER BALANCE MODEL:

Madhya Pradesh state is situated within 18^{0} N to 25^{0} N and 74^{0} E to 82^{0} E experiences tropical climate. Frontispieces give the orographic feature of the state. Geographical location and orographic features have profound influence on the climate of area. As per IMD the year may be divided into four seasons. The winter season from January to February is followed by the summer season from March to May. The period from June to September constitutes the southwest monsoon season and the period from October to December form the post monsoon season. Relevant rainfall data of state is given in **Figure 5.1** as climate of Madhya Pradesh. The climate water balance model of Hurdul Nala and mine area has been done using input data of monthly rainfall and potential evapotranspiration value.

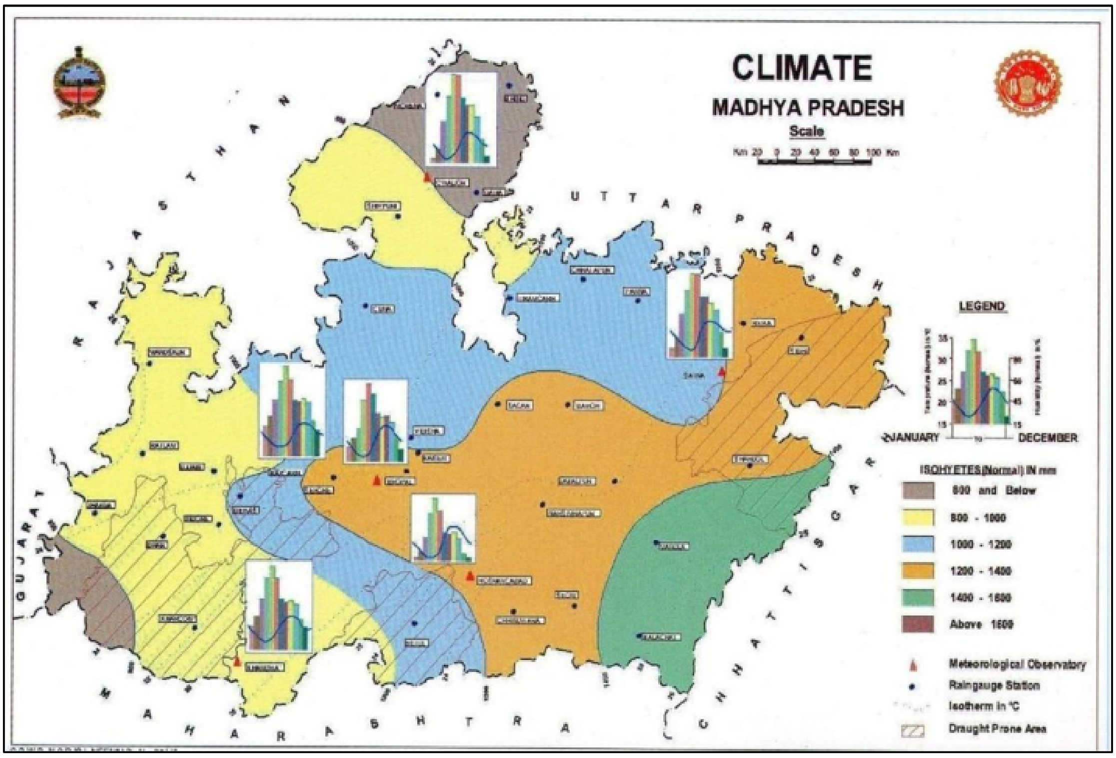


Figure 5.1: Rainfall of Madhya Pradesh

The Climatic Water balance is

P = AE + R $\underline{+}$ ΔS

P = Precipitation in mm

AE = Actual Evaporation

R = Runoff

$\underline{+}$ ΔS = Change in Storage

The Output of climate water balance model is to obtain site specific runoff coefficient.

5.1 Monthly Rainfall:

Rainfall data of nearest mine site at Singrauli is collected for the project and given in (**Table 5.1)** & graphically depicted in **Figure 5.2.** The average of 43 years data have been obtain to compare with normal monthly rainfall data of Sidhi IMD Station.

Table 5.1: Year wise rainfall data (1970 to 2021): Singrauli

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1970	28.5	0	14.6	0	0	86.6	244	NA	248.4	0	0	0	622.1
1971	0	11.4	9.2	6.3	17.6	172.2	348.5	164.4	109.4	13.4	0	0	852.4
1972	0	27.6	0	0	0	34	NA	509.4	164.2	0	42.4	0	777.6
1973	0	35.2	0	0	5.8	82.4	87.4	182	157	0	0	0	549.8
1974	0	5.8	1.6	0	3.4	90.5	390	218.1	127.8	46.6	16.4	0	900.2
1975	18.8	3.2	22.2	0	0	83.8	274.4	521.6	124.6	132.2	0	0	1180.8
1976	0	10	0	0	0	42.2	353.4	207.2	147.6	0	0	0	760.4
1977	18	3.8	1.2	31.4	27.2	224.4	298.3	304.2	227	30	0	0	1165.5
1978	36.8	98.8	28.6	10	0	179.2	341.2	386	403.6	14	0	0	1498.2
1979	0	0	0	0	0	44.8	179.4	NA	43.8	0	36.8	0	304.8
1982	101	22.8	29.6	0	9.8	94.8	182.4	431.2	58	9	7.8	0	946.4
1988	0	0	0	0	0	226.7	367.8	130.8	130.2	9	0	0	864.5
1989	0	0	8.6	0	0	227.6	292.4	221.2	130.6	0	14.6	14.6	909.6
1990	0	42.8	29.2	0	24	206.5	234.1	193	227.2	39.8	0	4.6	1001.2
1991	4.8	33.2	39.8	1.4	7.6	177.7	259.2	307.4	236.9	4.2	0	17.6	1089.8
1992	0	0	0	0	0	7.1	166.3	242.8	105.2	7	0	0	528.4
1993	0	12.8	0	0	0	78.6	180.5	122.7	211.4	6.6	0	0	612.6
1994	0	12	0	6.4	0	313.4	280.6	430.5	289	82.6	0	0	1414.5
1995	17.1	0	0	0	0	79.9	104.4	287.2	184	0	0	5	677.6
1996	0	0	0	0	0	22	NA	542	113	0	0	0	677
1997	0	0	0	0	0	110.1	267.4	505	97.8	52.2	0	59	1091.5
1998	38.5	0	18.6	0	0	18.2	180.8	304.8	208.2	28	0	0	797.1
1999	0	0	0	0	0	202.8	443.2	309.4	337.6	26.7	0	0	1319.7

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
2000	0	0	0	0	0	89	460	303	427	0	0	0	1279
2001	0	0	0	0	6	194	554	193	101	154	0	0	1202
2002	0	11.5	0	0	31.9	92.8	129.4	292.8	252	60	0	0	870.4
2003	6	52	0	0	0	162	219	599.6	429.3	66.1	0	0	1534
2005	3	47	0	0	5	189	322	273	142	18	0	4	1003
2006	0	0	76	19	0	59	314	431	52	0	29	0	980
2007	0	91	53	10	0	82	238	181	249	44	0	0	948
2008	26	6	0	7	28	150	152	243	61	5	0	0	678
2009	2	0	0	0	0	4	234	210	169	64	90	0	773
2010	0	0	0	0	1	10	364	216.2	215	0	1	0	807.2
2011	0	0	0	0	0	332.4	267.8	433	484.4	8.3	0	0	1525.9
2012	42.6	0	0	0	0	83.2	400.1	516.5	337.4	0	25	0	1404.8
2013	0	56.5	25	0	0	109.7	456.5	161.9	91.3	130	0	0	1038.9
2014	19	23	32.3	0	0	70	225	161.8	126.2	41	0	0	911.7
2015	40.8	0	66	21.1	3	5	232.7	298.4	18.3	52	0	2.3	739.6
2016	18	3.7	10	0	7	74.5	394.7	415.3	272.1	103	0	0	1298.3
2017	6	7.3	7.5	0	24	97.7	368.8	126	218	11.6	0	0	866.9
2018	0	5.6	0	3.5	9	56.6	314.4	385.5	141.6	0	0	8	924.2
2019	13.4	13	37.1	21.8	7.4	68.8	334.5	407.7	400.3	33.8	0	57.2	1395
2020	25	38.2	32.6	15	57.5	335.9	217.5	272.7	235.8	54.7	4.9	5.1	1452.7
2021	1.5	1	0	0	79.6	329.4	281.7	605.2	216				1515.02

(Source - Singrauli Dist. Office)

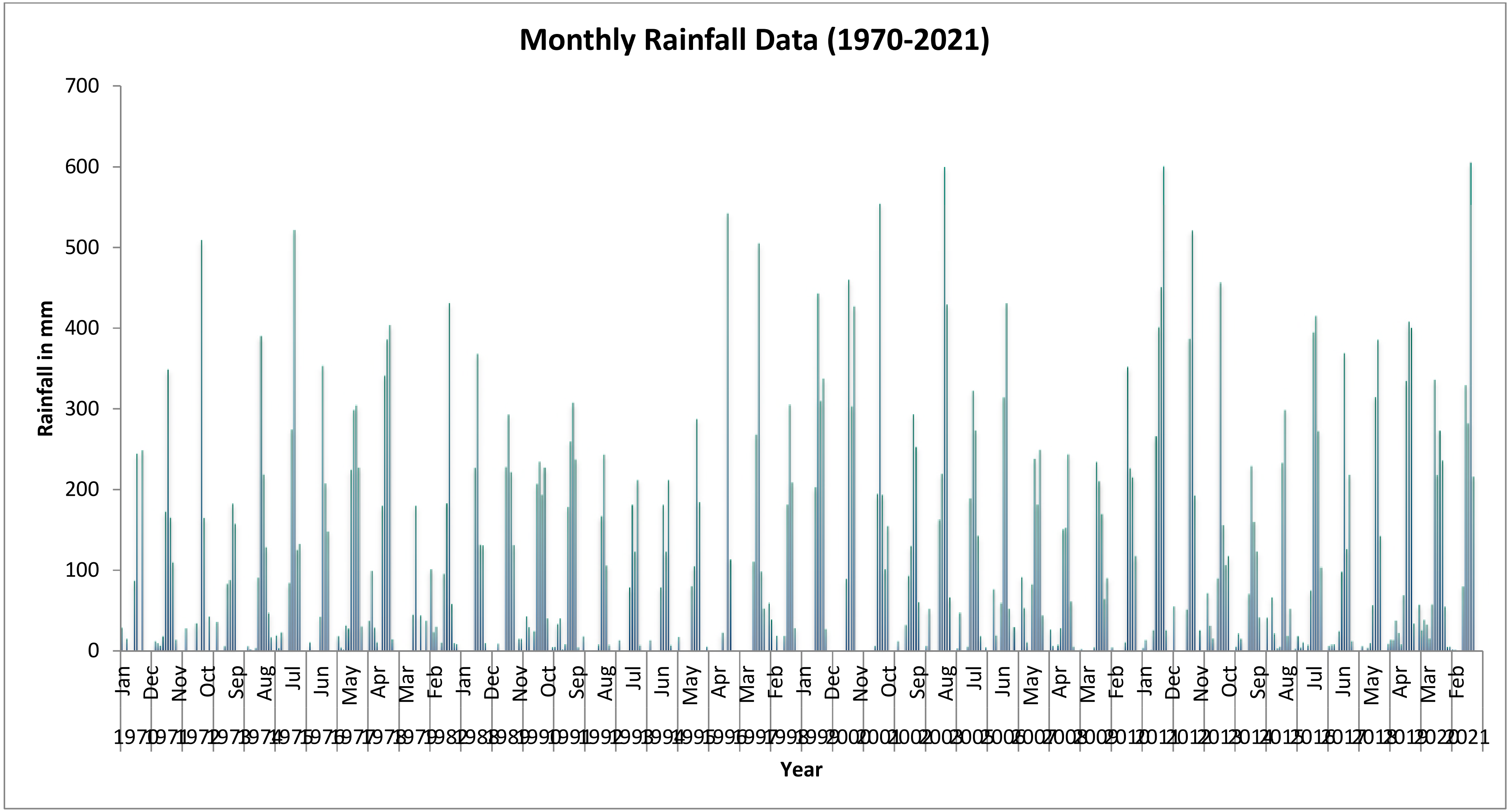


Figure 5.2: Monthly Rainfall Data of Singrauli District

5.2 Annual Rainfall:

The data are subjected to analysis for average and normal rainfall of the area, and have been plotted and found almost same in **Table 5.2 & Figure 5.3**. The average value of rainfall over period is 1124.1 mm. The study shows that normal rainfall data of nearest IMD station at Sidhi 1142.2 mm is almost matching with average value of Singrauli, where the deviation is well within limit of less than 10%. Accordingly normal rainfall value of Sidhi IMD station will be considered for study.

Table 5.2: Annual Rainfall of Singrauli District

Year	2010	2011	2013	2014	2015	2016	2017	2018	2019	2020	Average Singrauli	Normal IMD Sidhi
Annual Rainfall	807.2	1525.9	1038.9	911.7	739.6	1298.3	866.9	924.2	1395	1452.7	1124.1	1142.2

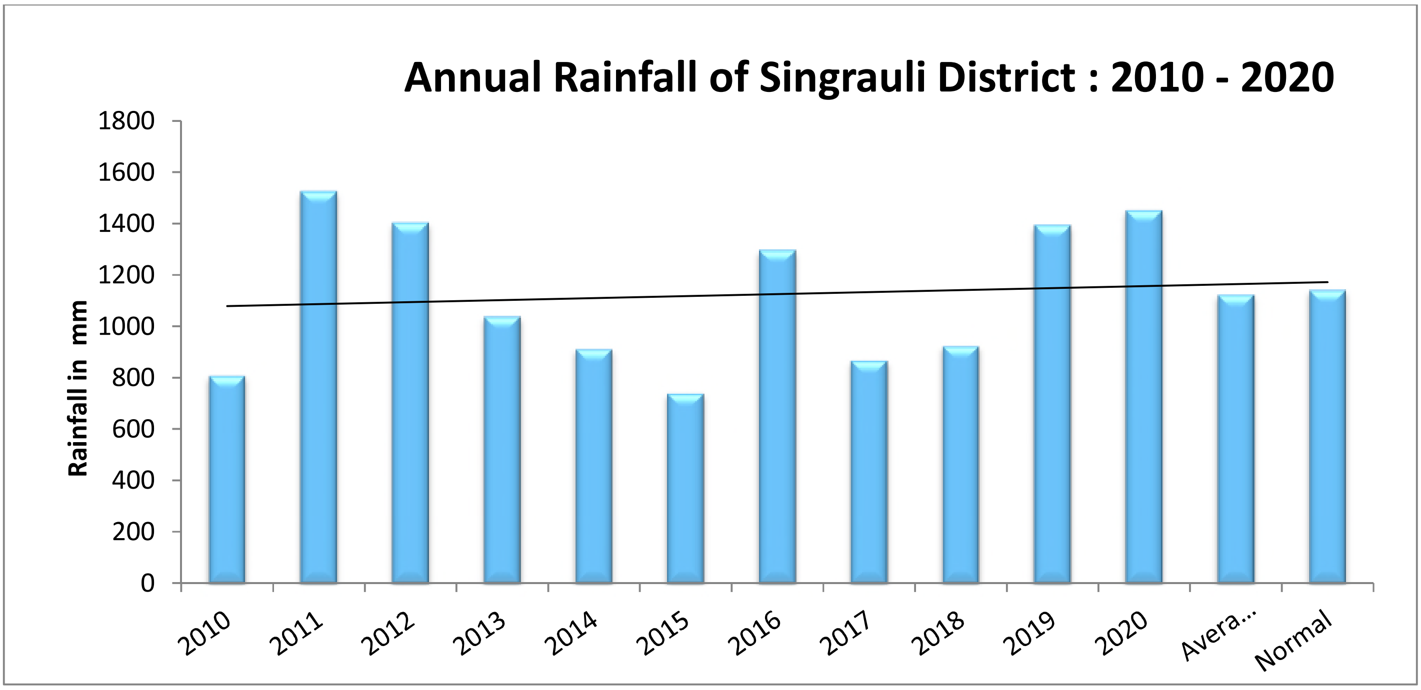


Figure 5.3: Annual Rainfall of Singrauli District

5.3 Normal rainfall in the study area:

The annual normal rainfall has been considered for Sidhi IMD station which is falling in Son sub-basin. As per IMD record the month wise normal rainfall based on recent 50 years is given in **Table 5.3** and depicted in **Figure 5.4.**

Table 5.3: Normal Rainfall in Sidhi Station

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Sidhi IMD Station	28.2	23.6	14.5	5.6	16.1	139.3	332.8	308.5	226	27.6	10.6	9.4	**1142.2**

(Source: IMD)

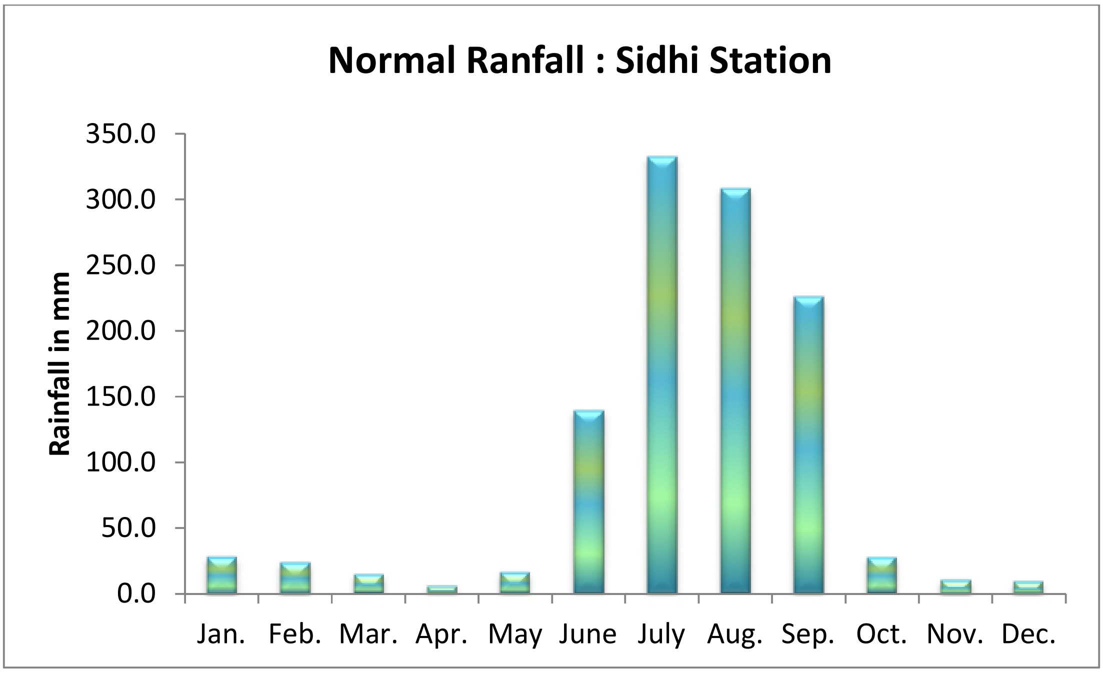


Figure 5.4: Normal Rainfall of Sidhi Station

The distribution of normal rainfall in Sidhi IMD station in given in **Table 5.4.**

Table 5.4: Distribution of Normal Rainfall of Sidhi

season	Sidhi	
	Rainfall in mm	**Percentage**
Monsoon	1006.6	88
Non-Monsoon	135.6	12
Total	**1142.2**	**100**

5.4 Monthly Rainfall Distribution:

The study of monthly rainfall surplus and deficit (**Table 5.5**) gives an idea about the spatial distribution of rainfall received in a year. The calculation of percentage deviation of the actual monthly totals from the theoretical monthly totals reveals monthly rainfall surplus or deficit. The value 8.3% has been assumed from the agro-climatic point of view which creates identical conditions for the growth of the perennial crops and also for adequate supply of water for other purposes, (**Figure 5.5)**. From the study based on this method it emerges that stations in study area have 4 months of rainfall surplus (June, July, Aug. Sept.) and 8 months of rainfall deficit (Jan. to May, Oct. to Dec.)

Table 5.5: Rainfall Surplus and Deficit Months

Method	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Theoretical	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	8.3	100
Calculation from normal	2.46	2.06	1.27	0.49	1.41	12.19	29.13	27.00	19.78	2.42	0.93	0.82	100
Deviation (2-1)	-5.84	-6.24	-7.03	-7.81	-6.89	3.8	20.83	18.7	11.48	-5.88	-7.37	-7.48	0

(-) Deficit months, (+) Surplus months

July is the month of heaviest rainfall which record 20.83% surplus rainfall in the area.

December is the lowest rainfall month which record (-) 7.48% deficit rainfall in the area.

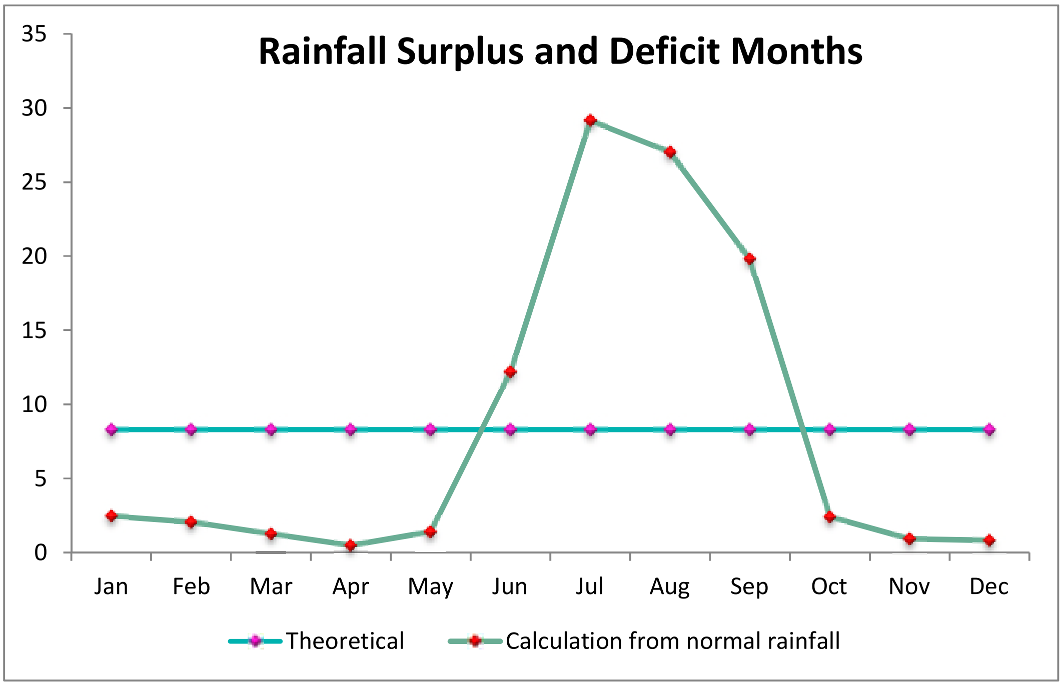


Figure 5.5: Rainfall Surplus and deficits month- Sidhi

5.5 Extreme Rainfall:

Extreme rainfall occurring in the area has been worked out by analyzing daily rainfall data of Sidhi station of the study area. Analysis has been published by IMD and the subsequent available data were also analyzed and the extreme rainfall occurring in the study area is tabulated in **Table 5.6.**

Table 5.6: Annual extreme rainfall & heaviest rainfall in 24 hours

Heaviest rainfall in 24 hours	
Amount mm	**Date**
238.6	9.09.1987

(Source: Climatological Table IMD)

Monthly extreme rainfall in 24 hours

Month	J	F	M	A	M	J	J	A	S	O	N	D
24 Hrs Rainfall mm	49.4	34.4	36.2	40.8	88.8	180.2	189.8	176.5	238.6	69.6	99.4	33.2
Date	21	28	12	19	06	07	16	08	09	11	11	02
Year	1971	1971	1990	1983	1982	1971	1980	1972	1987	1958	1969	1966

(Source: Climatological Table IMD)

5.6 Potential Evapotranspiration (PE):

Potential Evapotranspiration the value have been taken from IMD station. The area under study fall in Son sub zone 1(d). Same will be used for climatic water balance study. The monthly and annual PE value is given **Table 5.7** and same is depicted graphically in **Figure 5.6.**

Table 5.7: Potential Evapotranspiration

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
PET (PE)	63.8	84.2	137.0	173.0	213.0	191.3	120.0	107.6	114.0	114.0	75.0	58.0	1452.2

(Source: IMD)

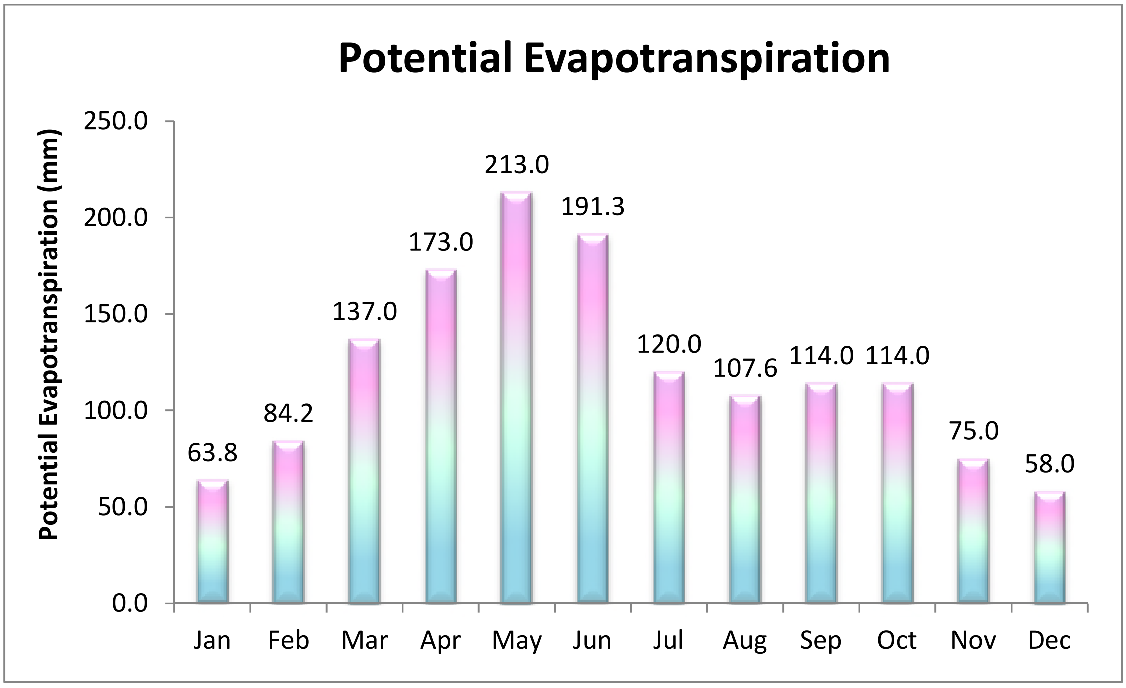


Figure 5.6: Potential Evapotranspiration Value

5.7 Climatic Water Balance:

The idea of climatic water balance was first put forth by Thornthwaite in 1944. Subsequently he developed water balance technique. Elements of climatic water balance for watershed located in and near the project area is computed in order to get firsthand information on actual evaporation, runoff and change in soil moisture of normal rainfall in the study area.

5.7.1 Water Balance Techniques:

The term "Water Balance" refers to the balance between the incoming water from precipitation and the outgoing water by evapotranspiration resulting in change of soil moisture and runoff. It is a climatic balance obtained by comparing the match of precipitation with evapotranspiration, yielding a number of moisture parameters like water surplus, water deficiency, soil moisture change and runoff. The basic relation governing the water balance concept is;

$P = AE + R \pm \Delta S$

Where,

P = precipitation in mm

AE = evaporation in mm

ΔS = change of soil moisture in mm

R = runoff in mm

An important feature of the water balance concept is the recognition of the part played by soil in the exchange of moisture between the earth's surface and the atmosphere. Soil-acts as a medium for storing water (up to a limit) in times of excessive rainfall and releasing the same (in a restricted manner) at other times for purposes of evaporation and transpiration.

5.7.2 Parameters for Computation:

To work out the water balance, three parameters are required:

i. Evapotranspiration (ET) (water need),

ii. Precipitation (P) (water supply),

iii. Available Water Capacity (AWC)

Evapotranspiration is the water loss from the earth's surface to the atmosphere -the sum of evaporation loss from soil and water surface and transpiration losses from vegetation. Evapotranspiration depends to a certain extent on the supply of moisture from the soil which can be evaporated and utilized by plant for transpiration. The water loss taking place from extensive vegetation cover under the ideal condition of continuously adequate soil moisture is termed as potential evapotranspiration (PE).

The potential evapotranspiration i.e. (PE) is essentially determined by available energy and is for all practical purposes independent of vegetation, soil or precipitation. It is a theoretical moisture loss which applies to any place but is only attained in reality where there is no shortage of water moisture.

5.7.3 Estimation of Potential Evapotranspiration:

There are various practical difficulties in measuring PE by Lysimeters and other devices. Consequently, PE is estimated by theoretical methods. Solar radiation, air temperature, wind and humidity are some of the chief factors that affect evaporation and transpiration. The annual PE value is 1452.2 mm in respect of Singrauli.

Monthly potential evapotranspiration does not show significant change from year to year. This is because; it is largely controlled by the input of solar energy of the month which remains constant from year to year. The contribution from the atmospheric drying power terms is much less compared to the radiation term. Thus, for all practical purposes, monthly potential evapotranspiration can be taken nearly constant for the entire area with a minor correction factor.

5.7.4 Precipitation:

Rainfall plays the most important role in water balance concept. Rainfall data required for computation has been dealt in detail in preceding chapter. Normal rainfall for 1142.2 has been taken from Table-2.2 for computation of climate water balance. The monsoon average rainfall of 1006.6 mm will be considered for groundwater resource estimation.

5.7.5 Soil Moisture:

During the period of excessive rainfall, the balance of water, i.e. left over after meeting the requirement of potential evapotranspiration, goes into soil to charge it. This process goes on till the soil attains field capacity. Any further addition of rainwater would become water surplus that flows out of the region as surface runoff or sub-surface or underground Drainage density.

Available water capacity (available water at field capacity) depends on the type of soil and depth of the root zone of the crop coupled with forest cover. For determining the available water capacity the type of soil of the area is found out from the soil map and corresponding to the soil type and the cereal grain crops, the value of available water is taken from the standard table of IMD. In general, the silty loam type of soil is available having moderate deep rooted crops. The available water capacity of such soil in Gondwana Sandstone has been taken as 200 mm per metre (Thornthwaite and Mather 1957). During the period of deficient rainfall soil moisture is used for evapotranspiration purposes. As soil dries, the rate of evapotranspiration decreases. According to Thornthwaite, 1957, the release of moisture is according to an exponential function given by;

$$S = AWC.\ Exp\ \frac{ACC(P-PE)}{AWC}$$

Where,

S = is the soil moisture remaining in the soil as storage

ACC (P-PE) = is the accumulated potential water loss (sum of negative P-PE value)

AWC = is available water capacity = 200 mm/meter

5.7.6 Water Balance Computation:

As mentioned earlier, in the water balance computation, precipitation (P) is compared with potential evapotranspiration (PE). On a monthly basis, P-PE can be zero, positive or negative. When P-PE is positive, actual evapotranspiration (AE) is equal to potential evapotranspiration (PE), as evapotranspiration can proceed unhindered with no water shortage. Negative (P-PE) value means potential loss of moisture from the soil. The actual loss of moisture from the soil will be at a potential rate or at a lesser rate as mentioned above. The actual evapotranspiration, in this case is equal to precipitation plus moisture actually lost from the soil.

The difference between potential evapotranspiration and actual evapotranspiration is water deficiency of the month after the soil has attained field capacity, the difference between precipitation and actual evapotranspiration which equal PE is the water surplus of the month. This surplus is the amount of water that is available for deep Drainage density as well as for runoff into streams, rivers and lakes. The part of this surplus only does actually runoff in the month. This has been taken as 50% of the surplus for the present study. The rest of the surplus is retained in the Watershed and becomes runoff during subsequent period.

5.7.7 Water Balance Table:

Using the method described in the above paragraph, the climatic water balance has been computed with the following information for the normal rainfall placed in table 5.3.

1. Potential evapotranspiration (PE)
2. Rainfall (P)
3. P-PE
4. Accumulated potential water loss (accumulated negative value of P-PE) = ACC (P-PE)
5. Storage (S)
6. Storage change (ΔS)
7. Actual evapotranspiration (AE)
8. Water deficit (WD)
9. Water surplus (WS)
10. Runoff (R_0)

5.7.8 Discussion on climatic water balance:

From the study of **(Table 5.8)** following important facts in respect of climatic water balance has emerged for study area.

Table 5.8: Climatic Water Balance of Singrauli (son) Watershed

Parameter	Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
PE	63.8	84.2	137	173	213.3	191.3	120.1	107.6	114.9	114	75	58	1452.2
P	28.2	23.6	14.5	5.6	16.1	139.3	332.8	308.5	226	27.6	10.6	9.4	1142.2
P-PE	-35.6	-60.6	-122.5	-167.4	-197.2	-52	212.7	200.9	111.1	-86.4	64.4	48.6	-310
ACCP-PE	-235	-295.6	-418.1	-585.5	-782.7	-834.7	0	0	0	-86.4	-150.8	-199.4	-3588.2

Parameter	Jan	Feb	Mar	April	May	Jun	July	Aug	Sept	Oct	Nov	Dec	Total
S	61.7	45.6	24.7	10.7	3.9	3.1	200	200	200	129.8	94.1	73.8	1047.4
ΔS	-12.1	-16.1	-20.9	-14	-6.8	-0.8	196.9	0	0	-70.2	-35.7	-20.3	197
AE	40.3	39.7	35.4	19.6	22.9	140.1	120.1	107.6	114.9	97.8	46.3	29.7	814.4
WD	23.5	44.5	101.6	153.4	190.4	57.2	0	0	0	16.2	28.7	28.3	637.8
WS	0	0	0	0	0	0	212.7	200.9	111.1	0	0	0	525
Ro	8.3	4.2	2.1	1.1	0.5	0.2	106.4	153.7	132.4	66.2	33.1	16.5	524.4

5.7.9 Water need of catchment (PE):

The annual potential evapotranspiration is taken as water need. The annual water need for 1452 mm. The annual water need of the country is ranging from 200 mm to 2000 mm. Thus, it is observed that the need is moderately high. The minimum and maximum monthly water need is ranging from 58 mm to 213 mm for the months of December and May respectively.

5.7.10 Actual Evapotranspiration (AE):

The actual evapotranspiration (AE) represent the amount of water loss actually taking place in the form of evaporation and transpiration. Monthly actual evapotranspiration is ranging from lowest value of 20 mm and highest value of 140 mm in the month of April and June respectively. The annual actual evapotranspiration for the normal being 814 mm. The annual actual evapotranspiration for all over India ranges from 100 mm to 1200 mm.

5.7.11 Water Deficiency (WD):

The extent to which the actual evapotranspiration falls short of the potential evapotranspiration is measured as water deficiency. The annual water deficiency estimated 638 mm. The monthly water deficiency starts from Oct. to May. The highest is 190 mm in the month of May, lowest water deficiency in the month of October is 16 mm. The annual water deficiency figures for all over India range from 50 mm to 1600 mm. In comparison to all India figures water deficiency figures are well within the limits.

5.7.12 Water Surplus (WS):

Water surplus is the amount by which precipitation exceeds actual evapotranspiration, when soil is at field capacity. In this area the water surplus is for three months viz. July, August and September. Monthly water surplus start in the month of July (213 mm), in the month of August (201 mm) and start declining in the month of September (111 mm). The annual water surplus is 525 mm. The annual water surplus of the country ranges from 100 mm to 2000 mm. The water surplus is moderate and also well within the limit.

5.7.13 Runoff (R):

Water surplus does not remain in the surface soil layer but goes off as surface runoff, deep percolation to water table or sub-surface flow. Information on the water surplus climatically determined from the water balance thus, provide a rough idea of stream flow which otherwise has to be obtained only from extensive stream gauging installation. Runoff is a monthly distribution of annual water surplus taking into account, as mentioned earlier, a 50% of the surplus water of the respective month goes actually as runoff in the subsequent month. The annual runoff is same as annual normal water surplus i.e. 525 mm. The monthly lean and peak runoff for normal rainfall is 0.2 mm to 154 mm in the month of June and August respectively.

5.7.14 Seasonal concentration of water surplus and deficiency:

The striking features of the water surplus and water deficiency are indicative of seasonal concentration of the rainfall which result frequent flash floods in area. Many of the small streams and nalas in the study area experience flash floods during peak monsoon months. The water in smaller capacity reservoir surplus in the Watershed is considered to be potential prospect for impounding of water for future use.

5.7.15 Water Balance Diagram:

The match of monthly potential evapotranspiration, precipitation, actual evapotranspiration and runoff is graphically represented in **Figure 5.7**. The graph shows period and amount of water surplus water deficiency and soil moisture utilization. This graph brings out climatic peculiarity of study area and helps in quick assessment of its water potential.

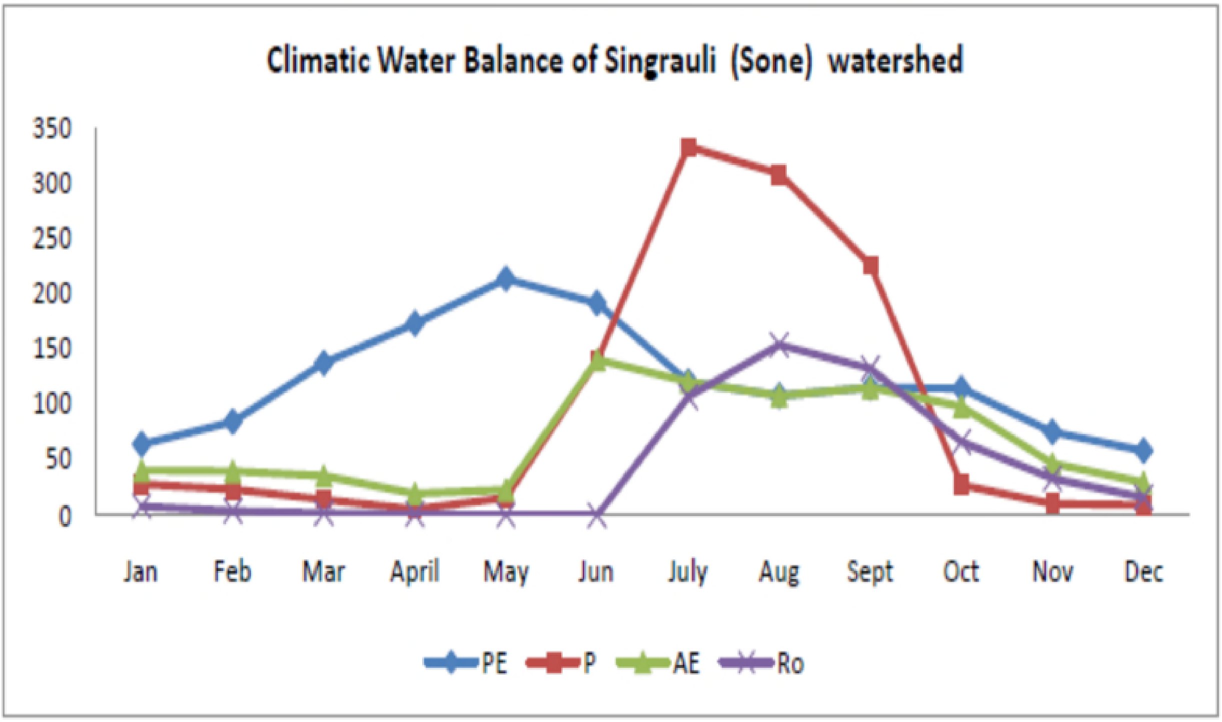


Figure 5.7: Water Balance Diagram

5.7.16 Water Balance Equation:

Water balance equation is computed in accordance with the techniques using the earlier described water balance data (**Table 5.9**). The water balance equation is equal for normal rainfall (mm).

P = AE + R + ΔS

1142 = 814 + 525 – 197

1142 = 814+328

Runoff Coefficient = 328 / 1142 = 0.2872

Table 5.9: Summarized Climatic Water Balance

Year	PE	P	P-PE	ACCP-PE	S	ΔS	AE	WD	WS	R
Normal	1452	1142	-310	-3588	1047	-197	814	638	525	525

Runoff Coefficient	= 0.2872

5.8 Discussion:

The climatic water balance model conclude that out of annual rainfall (1142 mm) actual evaporation (814 mm) will be 71% and runoff will 29%. The pie diagram for actual evaporation (AE) and runoff (R) is depicted in **Figure 5.8.**

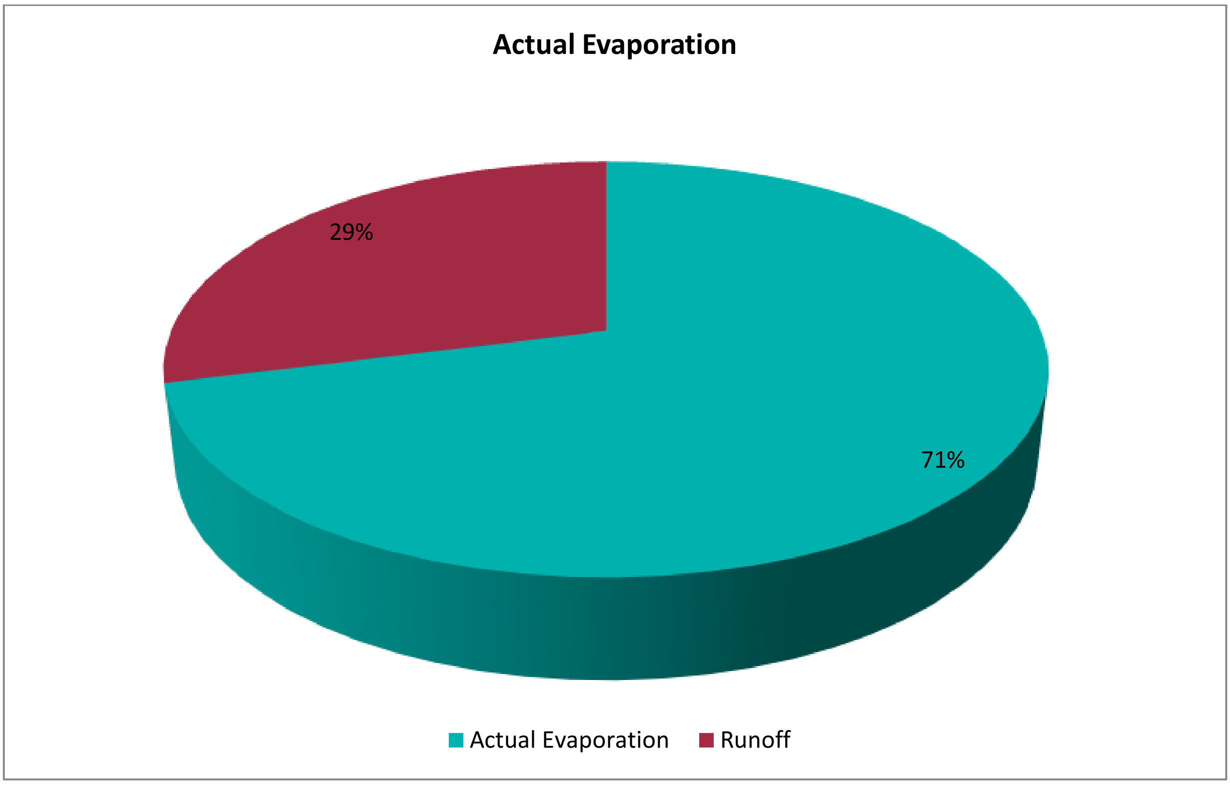
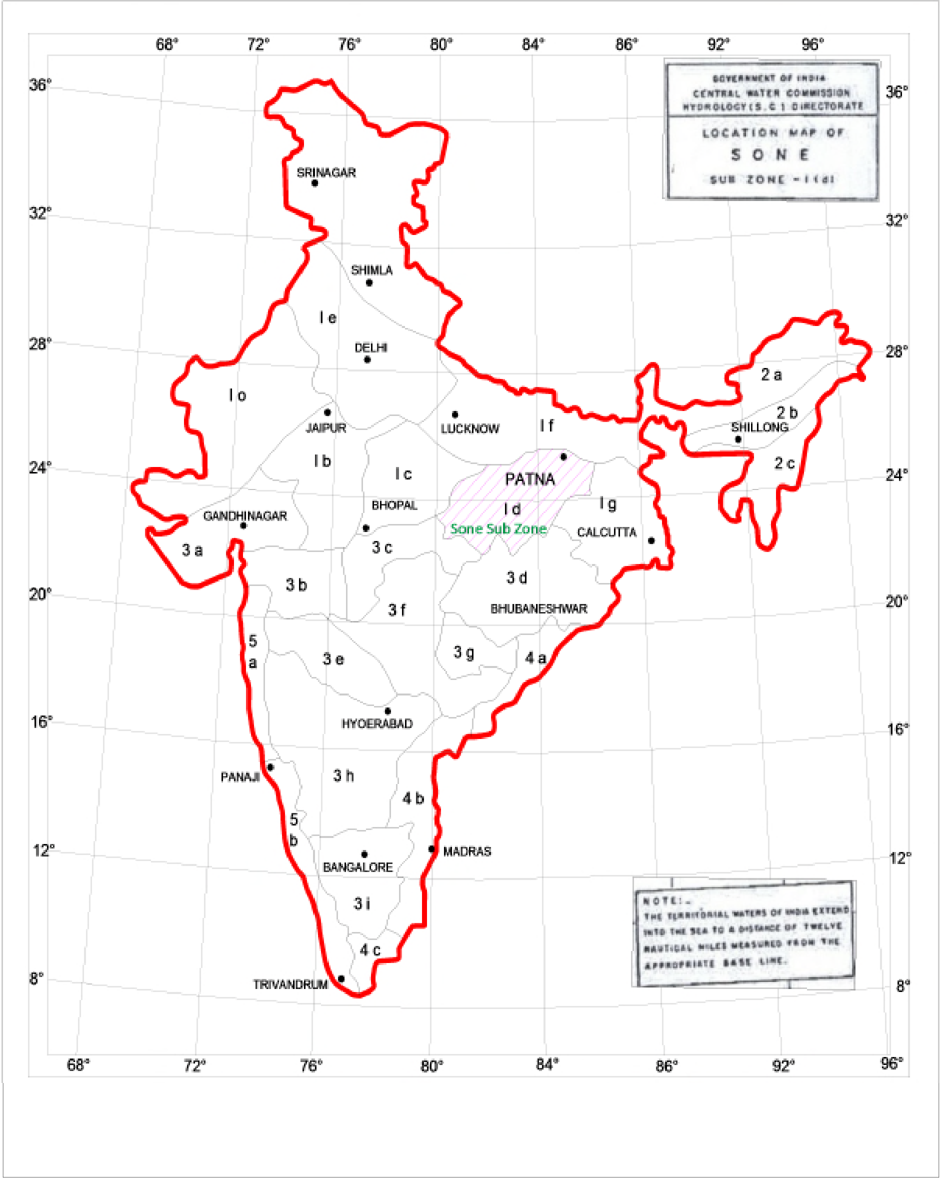


Figure 5.8: Climatic Water Balance

6.0 AREA DRAINAGE DENSITY:

6.1 Watershed of India:

The mine area is part of Sone sub – basin. The central water commission has classified it as Sone sub zone – 1 (d). The watershed of India is given in **Figure 6.1** with reference to Watersheds of India.



(Source- CWC)

Figure 6.1: Watershed of India

6.2 Sone Watershed:

The Drainage density basin of sone sub zone (d) is given in **Figure 6.2.** The location of Gopad Watershed within sone sub zone is also depicted in this map.

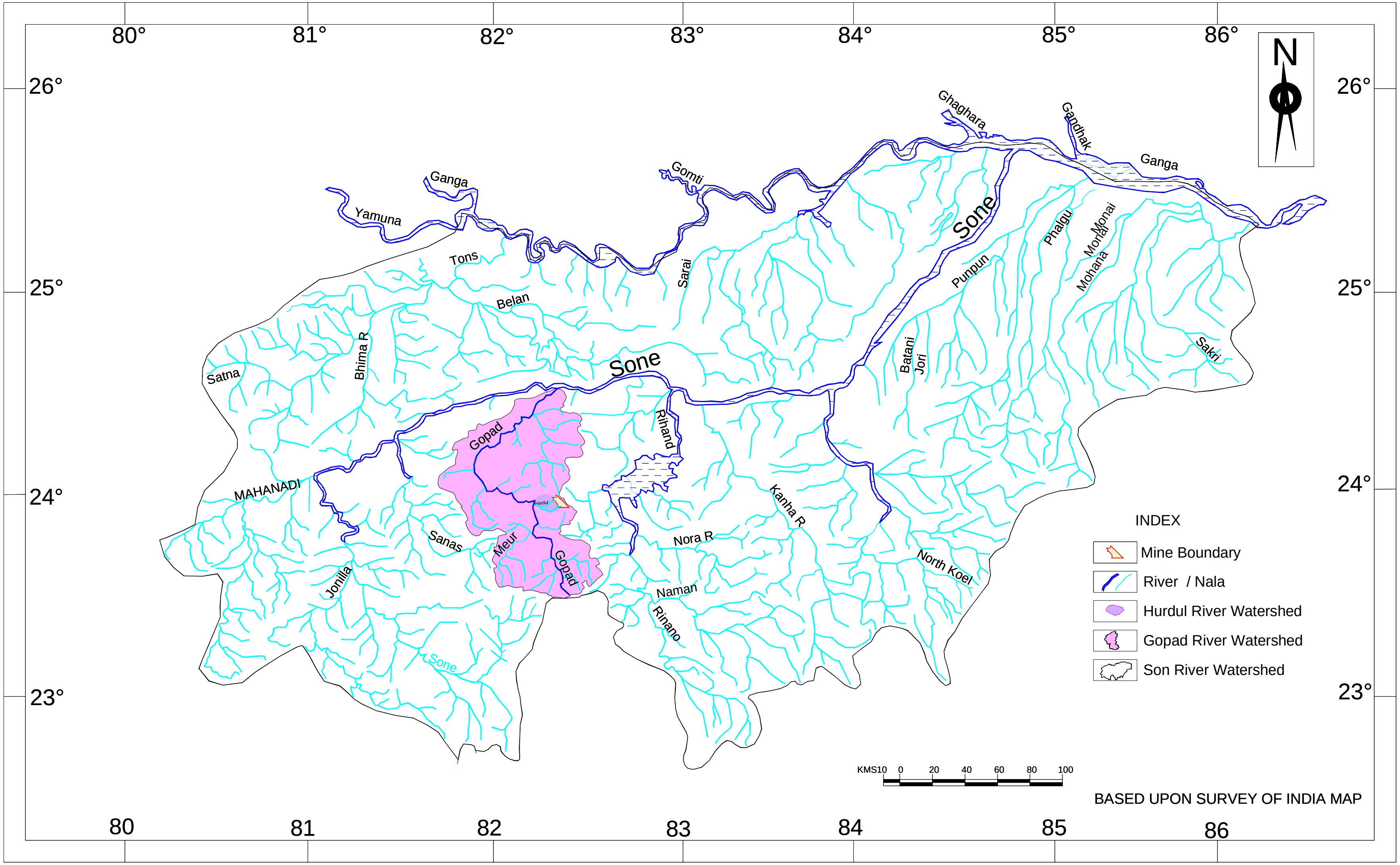


Figure 6.2: Drainage density Basin of Sone Watershed

6.3 Gopad Watershed:

The Drainage density basin of Gopad watershed is given in **Figure 6.3.** The Hurdul Nala is part of Gopad Watershed. The watershed of Hurdul Nala is also depicted in this map.

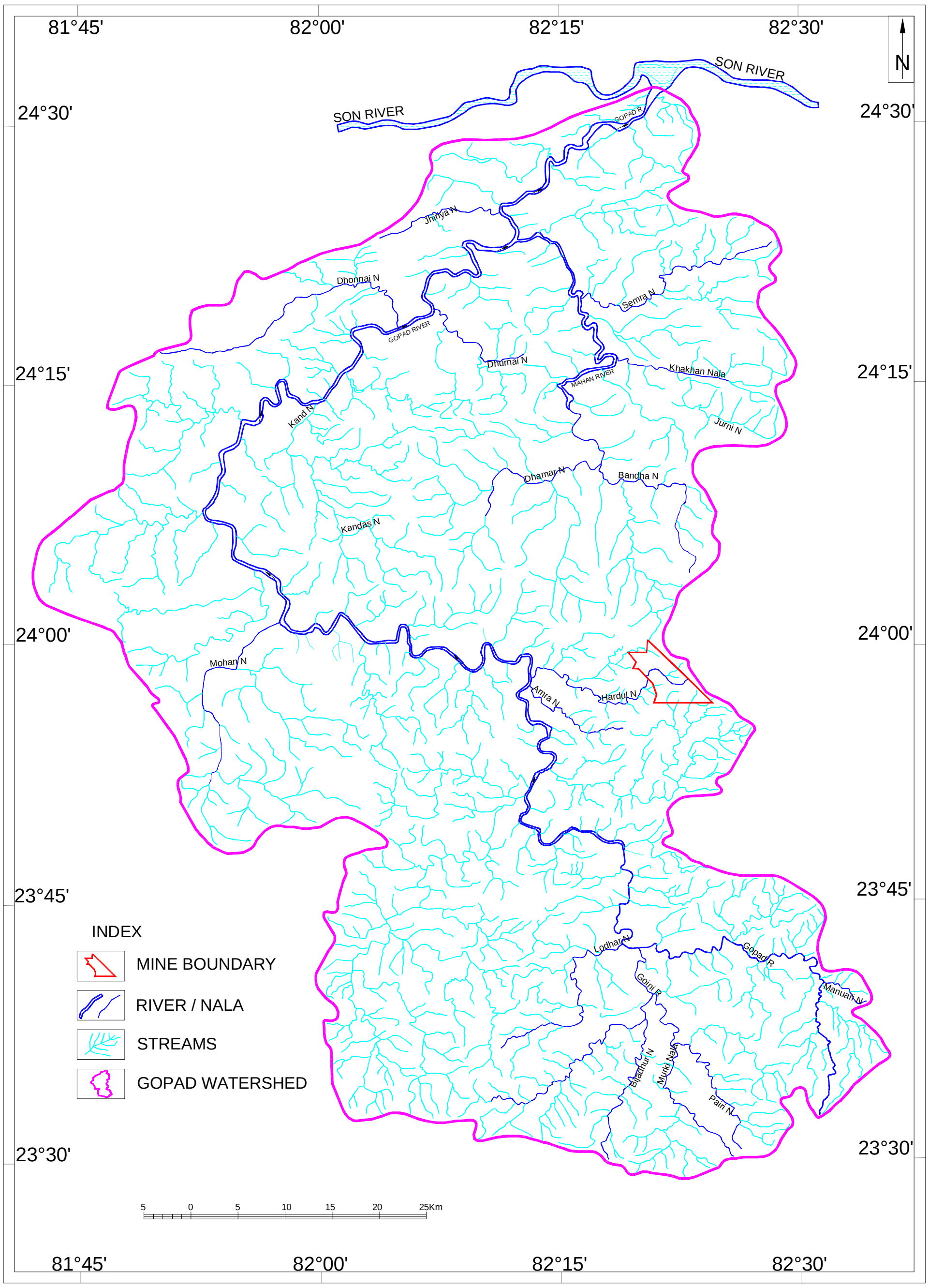


Figure 6.3: Drainage density basin of Gopad Watershed

6.4 Hurdul Nala Watershed:

The Drainage density basin of Hurdul Nala along with location of Dhirauli Mine is given in **Figure 6.4.**

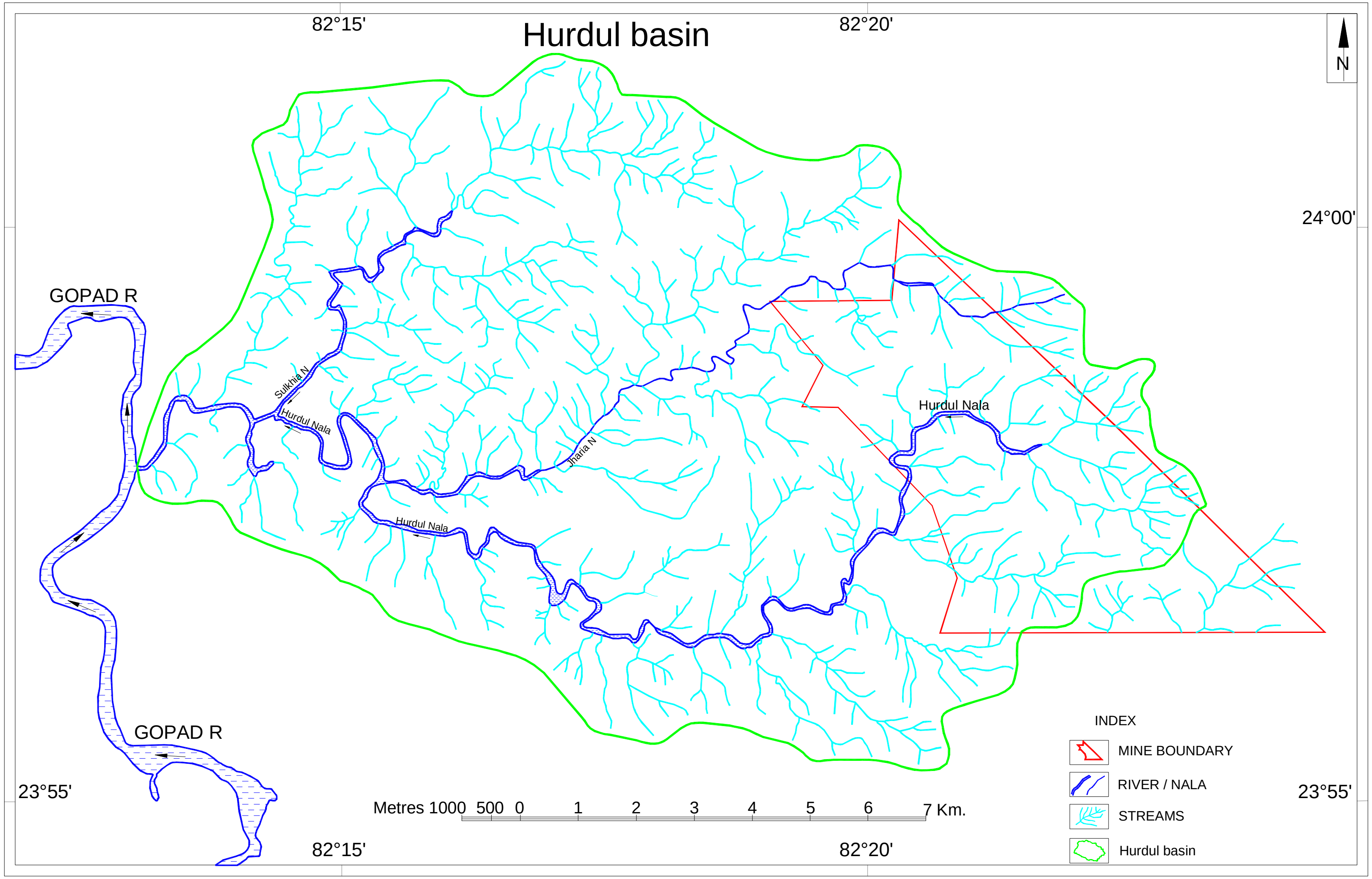


Figure 6.4: Hurdul Nala Watershed

6.5 Mine Watershed:

The Drainage density of Dhirauli Coal Block is considered in two categories.

1. External Drainage density of Mine Block
2. Internal Drainage density of Mine Block

The both external and internal Drainage densitys are part Hurdul Nala watershed. The Drainage density of mine is shown in **Figure 6.5.**

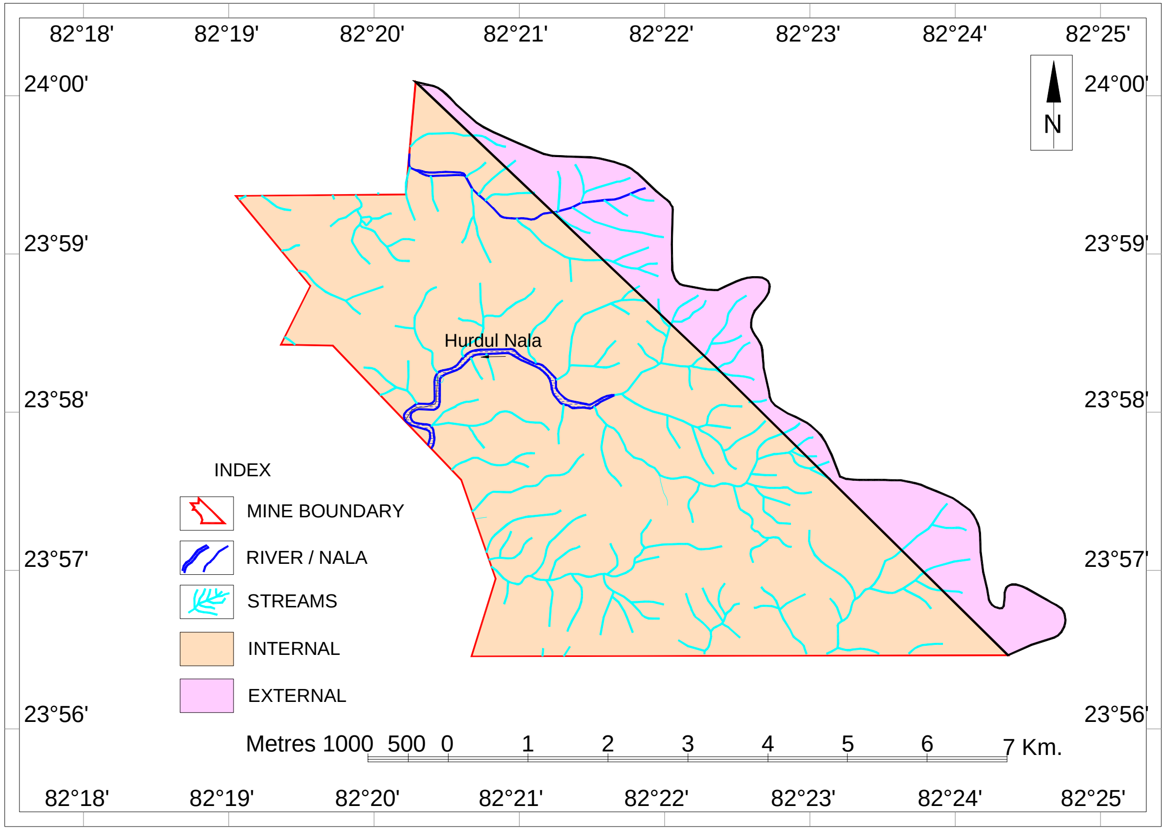


Figure 6.5: Map of External and Internal Drainage density - Part of Hurdul Nala Watershed

6.6 Stream Gauging Watershed:

The stream gauging for Dhirauli Coal Block modeling is being done. The watershed occupied by stream gauging station is shown in **Figure 6.6.**

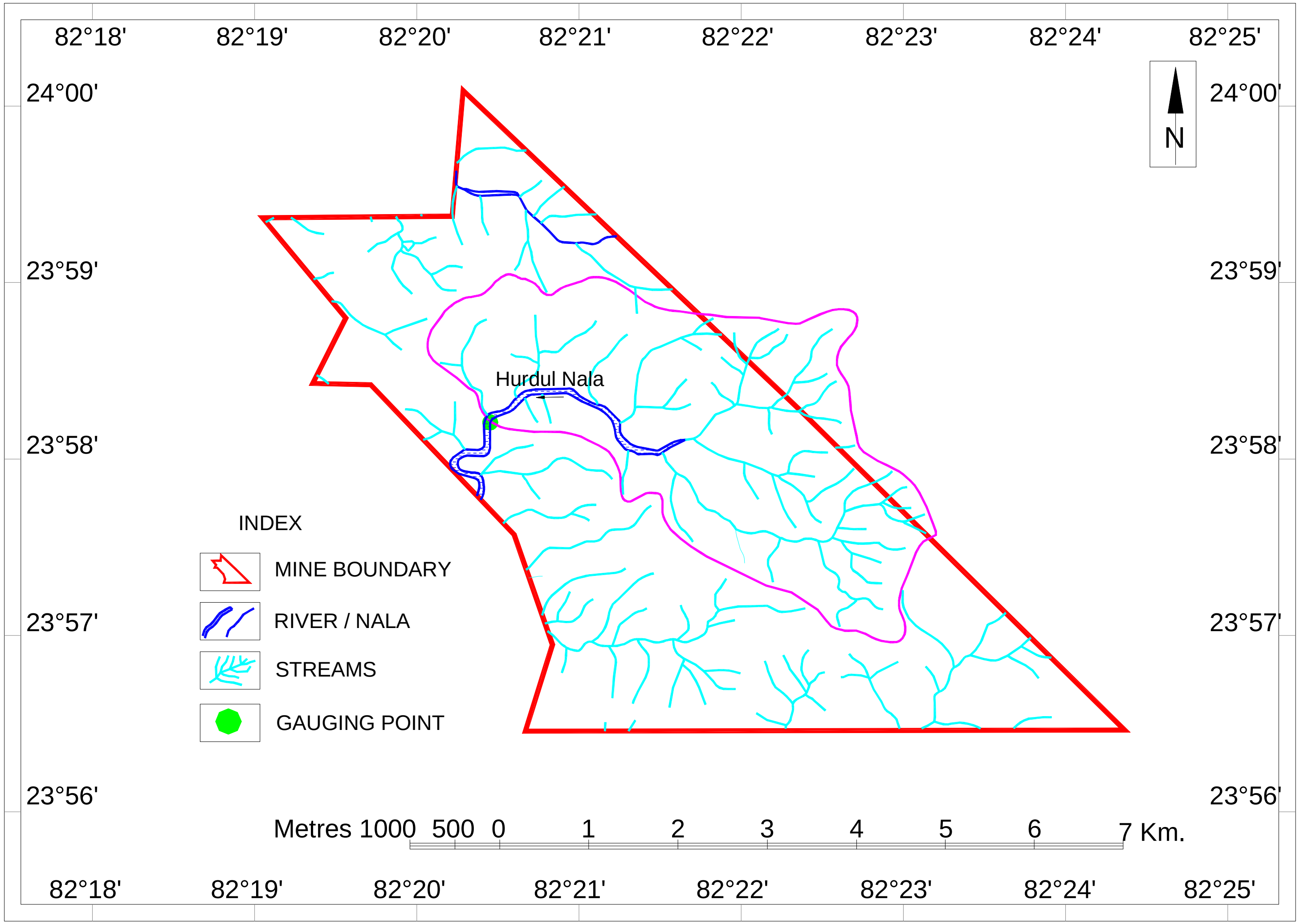


Figure 6.6: Stream Gauging Watershed

6.7 Area of Drainage densitys:

The area of different watershed is given in **Table 6.1.**

Table 6.1: Area of Drainage densitys

Sr. No.	Watersheds	Area in km^2
1	Sone	42,861
2	Gopad	6230
3	Hurdul	134
4	Mine Watershed	33.42
4(a)	Mine Internal	26.72
4(b)	Mine External	6.70
5	Stream gauging Watershed	11.00

6.8 Morphometric Analysis of Hurdul Watershed:

Morphometric analysis of watershed is done to know the formation of watershed by geological structure or by erosional factor. Morphometric parameters such as Drainage density density, stream order, and area and stream length provide a basis for evaluation of runoff and ground water potentials of basins. a details description of the method of morphometric analysis of basin characteristic is given by Horton (1932) et al. The basin characteristics of Hurdul Nala up to core zone have been analyzed. Morphometric analysis of basin along with data of digital elevation models and GIS tools Study is placed in **Table 6.2.**

Drainage Density:

Horton (1932), introduced the watershed density (Dd) is an important indicator of the linear scale of land form elements in stream eroded topography. It is the ratio of total channel segment length cumulated for all order within a basin to the basin area, which is expressed in terms of Km/Km^2. It describes the spacing and distribution of the Drainage density ways in a catchment. The Drainage density (Dd) of study area is 1.60 Km/Km2 indicating moderate Drainage densities. Drainage density is define as the total length of channel in a Drainage density basin divided by the total area, represented by the following equation,

$Dd = \frac{\sum L}{A}$,

For diverted nala trench-

L= 10.72 km, A= 6.70 km^2,

$$Dd = \frac{10.72}{6.70} = 1.60\ km/km^2$$

For Hurdul Watershed –

$$Dd = \frac{214.97}{134.20} = 1.60\ km/km^2$$

Where Dd is Drainage density density, A is total area of basin and L is total length of Drainage density.

Bifurcation Ratio:

Strahler's system, which is a slightly modified of Hortons system, has been followed because of its simplicity, where the smallest, unbranched fingertip streams are designated as 1st order, the confluence of two 1st order channels give a channels segments of 2nd order, two 2nd order streams join to form a segment of 3rd order and so on. When two channel of different order join then the higher order is maintained. The trunk stream is the stream segment of highest order. Stream order is a method of assigning a numeric order to links in a stream network. Stream order of basin area is given in **Table 6.2** and a graph is plotted stream order vs log no. The bifurcation ration is calculated by the formula suggested by Horton.

Rb = Log $0.55^{(-)}$

Rb = 3.54

Horton observed *"bifurcation ration characteristically ranges from 3 to 5 for watershed in which geological structure does not distort the drainage pattern"* from this it can be concluded that above value 3.54 of bifurcation ratio indicate the geological structure has not affected the Drainage density pattern of Hurdul Nala watershed (basin). The drainage pattern developed may be due to elevation difference and more erosional activity.

Table 6.2: Morphometric Analysis of Hurdul Watershed

Order of Stream	Stream No.	Log No.	Stream Length (Km)
1	179	2.25	110.92
2	42	1.62	54.65
3	6	0.79	18.51
4	3	0.48	24.04
5	1	0	6.85
Total			214.97

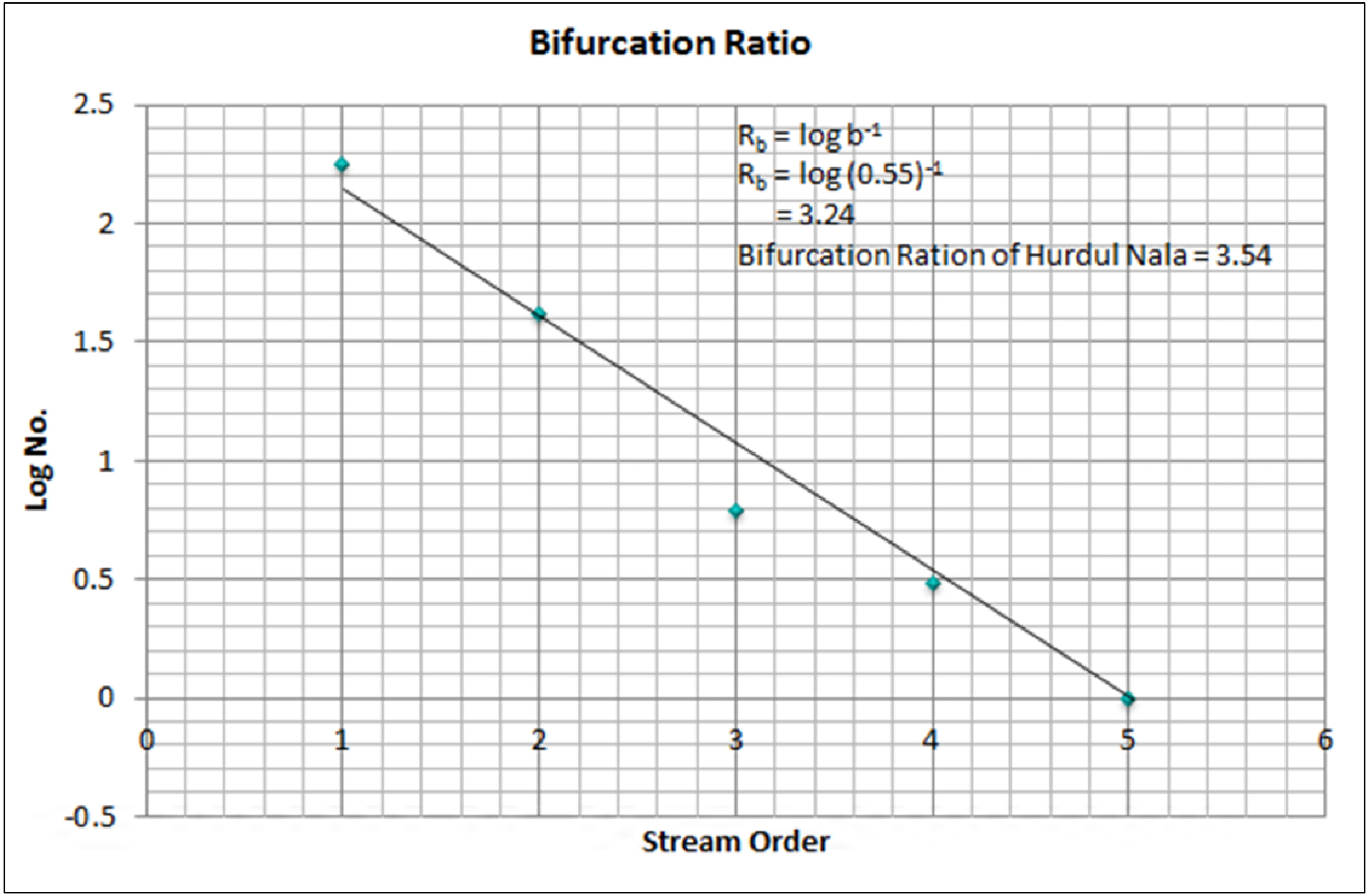


Figure 6.7: Bifurcation Ratio

6.9 Infiltration:

Infiltration is the flow of water into the ground through the soil surface. Since infiltrated water may contribute to the groundwater discharge in addition to soil moisture, the process can be schematically modeled where two situation, viz. low intensity rainfall and high intensity rainfall are considered. It is recorded that in case of low intensity rainfall, there will be no contribution to groundwater flow. Whereas in the case of high intensity rainfall, there will be contribution to groundwater flow.

The infiltration characteristics of a soil at a given location can be estimated by using flooding infiltrometer. The flooding type infiltrometer are experimental devices knows as double ring infiltrometer and used to obtain data relating to variation of infiltration capacity with time.

Double Ring Infiltrometer: This is most commonly used infiltrometer is designed to overcome the basic objectives of tube infiltrometer viz. tube area is not representative of infiltration area. In this case, two sets of concentrating rings with diameter of 30 cm and 60 cm and of a maximum length of 25 cm are used. The two rings are inserted into ground and water is applied in both the ring to maintain a constant depth of about 5.0 cm. The outer ring provide water jacket to the infiltrating water of the inner ring. The water depth in inner and outer ring is kept the same during the observation period. The measurement of water volume is done on the inner ring only. The experiment is carried out till constant infiltration rate is obtained.

A perforated disc to prevent formation of turbidity and settling of fines on the soil surface is provided on the surface of the soil in inner ring as well as in the annular space of outer ring. The experiment for infiltration test was carried out in one location. The locations of infiltration tests are given in **Table 6.3.**

Table 6.3: The locations of infiltration tests

Sr. no.	Location
I-1	Near Stream Gauging Station

The infiltration test data of different locations were processed and summarized in **Table 6.4** and depicted in **Figure 6.8.**

Table 6.4: Infiltration Test Data

Time since start	Minutes	0	10	20	30	45	60	90	120	150	180	210	Constant Infiltration rate cm/hr	Infiltration zone
	Hour	0	0.16	0.33	0.5	0.75	1	1.5	2	2.5	3	3.5		
Infiltration rate (cm/hr) Site	I-1	0	9	3.01	2.5	2.1	1.8	1.5	0.8	0.7	0.6	0.6	**0.6**	**Low**

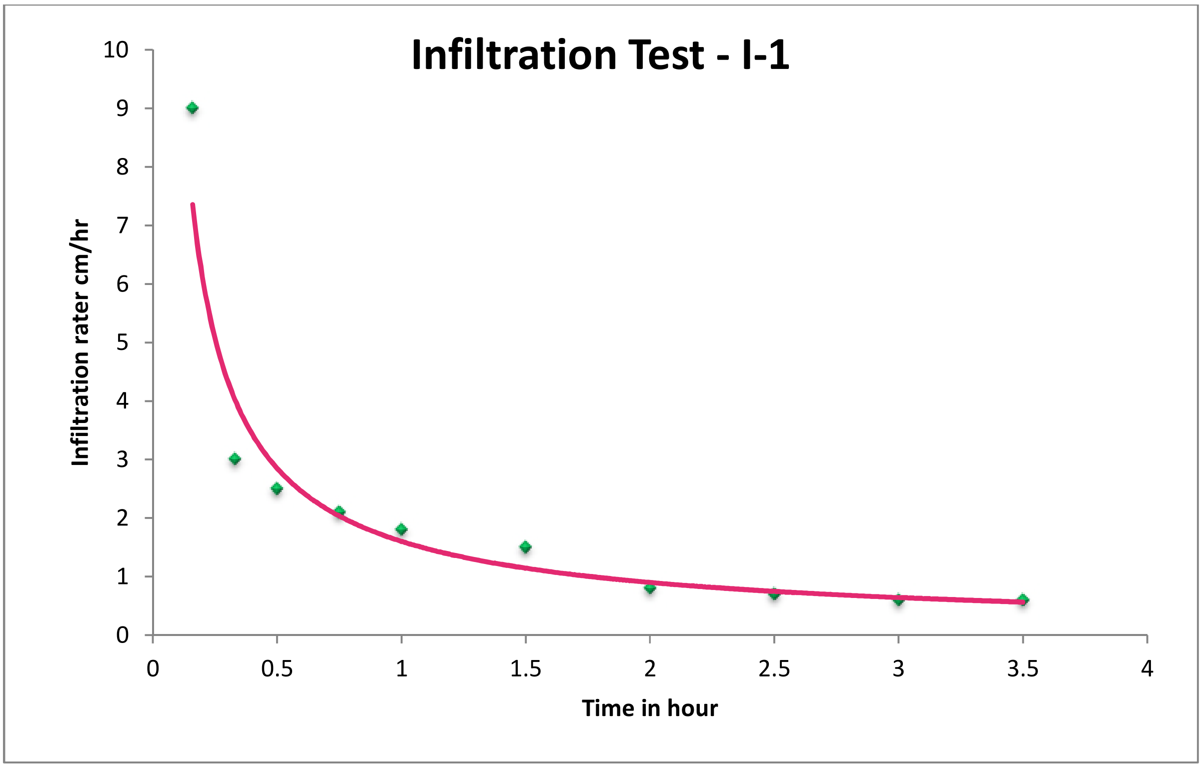


Figure 6.8: Infiltration Test I – 1

The results of infiltration experiment was analyzed and inferred that the infiltration rate of 0.60 cm/hour is indicative of sandstone formation having very low infiltration capacity of rainfall. **The characteristics of soil are indicative of wet clay loam.** This may be as the infiltration test was done during monsoon period.

7.0 HYDROLOGY:

7.1 General:

Hydrology means science of water. The various aspect of water related to surface can be explained in term of a cycle known as hydrological cycle. The hydrological cycle is explained in **Figure 7.1.** The runoff measurement is main task for formulation of stream water flow in this mine. The Hurdul Nala is non-gauged stream. Consequently there is no stream flow data available hence exercise of runoff measurement is to be done for TOR Compliance.

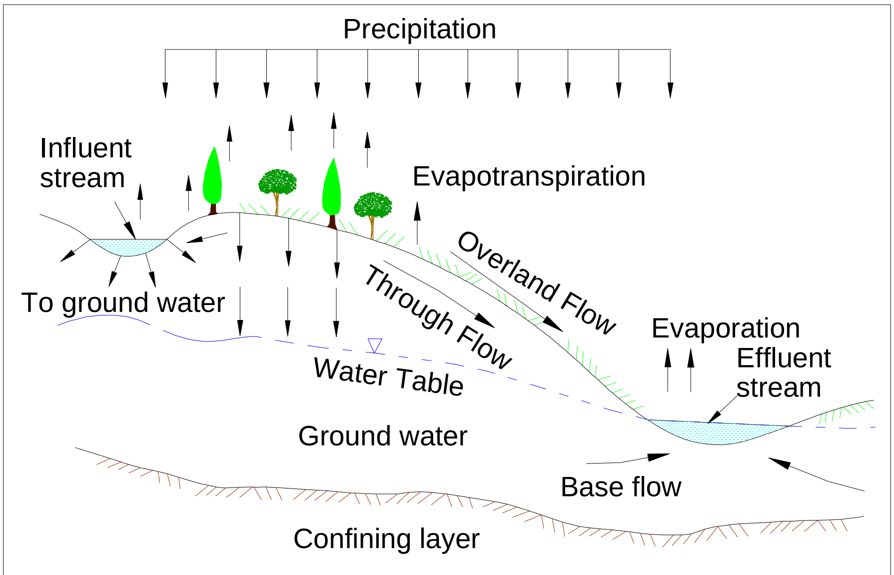


Figure 7.1: Hydrological Cycle

Runoff Measurement:

There are two methods of runoff measurement

1. Direct Stream flow Measurement
2. Indirect Method of Stream flow measurement by modeling and empirical formula

7.2 Stream Flow Measurement:

Stream flow representing the runoff phase of the hydrologic cycle is the most important basic data for this study. This will help to validate the Hydrologic Modeling. Stream flow measurement is represented by unit m^3/sec occurring at specified time and constitutes historical data. The area velocity method has been opted for stream flow measurement. The details of site of gauging are given below.

1.	Coal Block	:	Dhirauli Coal Block
2.	Period of Operation	:	Two Months (Aug & September)
3.	Name of Sub Zone of CWC	:	Sone Sub Zone 1(d)

4.	Name of Watershed	:	Hurdul
5.	Shape of Catchment	:	Fall
6.	Site Location	:	Dhirauli
7.	Location (Toposheet – 64I/5)	:	23^o 58' 11.83"(N)
		:	82^o 20' 20.89"(E)
8.	Soil	:	Red loamy soil
9.	Geology	:	Lower Gondwana Sandstone / Shale Coal
10.	Nala Bed at Gauging station	:	RL 476 m a msl

Area Measurement at Gauges site:

The topographic contour survey of 1 m is done in nala to stable bed. The stage measurements are made through ranging rod and mark on pillar of bridge. The area is calculated based on base RL value and top water level RL value at the interval of 1m. The area is estimated on daily basis.

Time of Measurement: In normal rainy days the measurement is done twice/day. In heavy rainy days the measurement is done hourly basis for 12 hrs in day or flow is stabilized.

Measurement of Velocity:

The measurement of velocity is important aspect of direct stream flow measurement technique. A mechanical device current meter has been used for measurement of velocity.

Stream Flow Data: Average stream flow data in m^3/sec for the period of 13/8/2021 to 30/09/2021 is given in **Table 7.1**. The peak flood runoff on 19/08/2021 is recorded separately for hourly basis and given in **Table 7.2.**

Table 7.1: Measurement of Stream Flow by Area Velocity Method – Dhirauli Coal Block

Date	Area m^2	Velocity m/sec	Runoff m^3/sec	Rainfall mm
13/Aug/21	0.08	0.00	0.00	0
14/Aug/21	0.08	0.00	0.00	0
15/Aug/21	0.08	0.00	0.00	0
16/Aug/21	1.6	0.69	1.10	4.4
17/Aug/21	0.08	0.00	0.00	0
18/Aug/21	12.4	2.14	26.50	106
19/Aug/21	15	2.39	35.82	123
20/Aug/21	6.4	1.64	10.50	45.2

Date	Area m^2	Velocity m/sec	Runoff m^3/sec	Rainfall mm
21/Aug/21	0.8	1.63	1.30	5.2
22/Aug/21	0.08	0.00	0.00	0
23/Aug/21	0.08	0.00	0.00	0
24/Aug/21	0.08	0.00	0.00	0
25/Aug/21	0.08	0.00	0.00	0
26/Aug/21	0.08	0.00	0.00	0
27/Aug/21	0.08	0.00	0.00	0
28/Aug/21	0.08	0.00	0.00	0
29/Aug/21	0.08	0.00	0.00	0
30/Aug/21	0.08	0.00	0.00	0
31/Aug/21	0.08	0.00	0.00	0
1/Sep/21	0.08	0.00	0.00	0
2/Sep/21	0.08	0.00	0.00	0
3/Sep/21	0.08	0.63	0.05	0.2
4/Sep/21	0.08	0.00	0.00	0
5/Sep/21	0.08	0.00	0.00	0
6/Sep/21	0.08	0.00	0.00	0
7/Sep/21	1.6	1.13	1.80	7.2
8/Sep/21	4.14	1.64	6.80	26.2
9/Sep/21	0.08	0.00	0.00	0
10/Sep/21	0.64	0.86	0.55	2.2
11/Sep/21	0.08	0.00	0.00	0
12/Sep/21	0.08	0.00	0.00	0
13/Sep/21	0.08	1.56	0.13	0.5
14/Sep/21	4	1.76	7.05	28.2
15/Sep/21	3.93	1.78	7.01	28.4
16/Sep/21	3.2	1.20	3.85	15.4
17/Sep/21	3.2	0.69	2.20	8.8
18/Sep/21	0.8	0.94	0.75	3
19/Sep/21	1.6	1.16	1.85	7.4

Date	Area m^2	Velocity m/sec	Runoff m^3/sec	Rainfall mm
20/Sep/21	0.8	0.47	0.38	1.51
21/Sep/21	0.08	0.00	0.00	0
22/Sep/21	6.4	1.77	11.35	45.41
23/Sep/21	1.6	1.00	1.60	6.4
24/Sep/21	0.08	0.00	0.00	0
25/Sep/21	4	1.89	7.55	30.2
26/Sep/21	0.08	0.00	0.00	0
27/Sep/21	0.08	0.00	0.00	0
28/Sep/21	1.6	0.88	1.40	5.6
29/Sep/21	0.08	0.00	0.00	0
30/Sep/21	0.08	0.00	0.00	0

Table 7.2: Stream flow on 19/08/2021-123 mm Rainfall

Time in Hours	Area m^2	Velocity m/sec	Runoff m^3/sec
0	0.8	0.3	0.242
1	0.8	0.53	0.426
2	5	0.98	4.92
3	15	2.39	35.82
4	14	2.33	32.68
5	14	1.89	26.42
6	13	1.58	20.56
7	12	0.98	11.73
8	10.5	0.87	9.1
9	8.1	0.77	6.24
10	4	0.75	2.98
11	1.6	0.98	1.56
12	0.64	0.78	0.5

7.3 Indirect Method of Stream Flow Measurement:

The portion of the precipitation which by variety paths above and below the surface of earth reaches the stream channel is called runoff. Once it enter stream channel, runoff become stream flow. It is thus represent output from the catchment in a given unit of time.

Dhirauli mine area is part of catchment of Hurdul stream. The runoff estimation of Hurdul catchment has been done for two time units.

Peak flood estimation

- One day heaviest rainfall
- Annual monsoon rainfall as annual runoff yield.

The peak flood estimation will be done by two methods

3. Mathematical Model by CWC
4. Empirical Methods

7.4 Mathematical Model for Peak Flood Estimation:

Central Water Commission (CWC) of Govt. of India have prepared mathematical model document for estimation of peak flood for sone sub zone 1(d) (**Annexure- 1A).** The steps suggested in CWC document have been followed. The peak flood estimation by unit hydrograph model has been done. The model is developed for Hurdul catchment area of 134 km^2 considering 50 years return period Isopluvial map of CWC & IMD for 24 hours rainfall. The actual flood measurement at Dhirauli Coal Block site has been done for the catchment area of 11 km^2. The same has been used for validation of model with proto catchment area and 24 hrs rainfall.

Unit Hydrograph:

The problem of predicting the flood hydrograph resulting from a known storm in a catchment has received considerable attentions. A large number of methods are proposed to solve this problem and one of them probably the most popular and widely used method is the unit hydrograph.

To develop unit hydrograph to a catchment, detailed information about the rainfall and resulting flood hydrograph are needed. However, such information is not available for the project due to paucity of time limit for study period. In order to construct unit hydrograph for this area, mathematical modeling for empirical equations of regional validity which relate the salient hydrograph characteristics to the basin characteristics are available for Sone Sub Zone (1 d) by Central Water Commission (CWC) Govt. of India. The unit hydrograph derived from such relationship are known as synthetic unit hydrograph.

Synthetic Unit Hydrograph:

The mathematical model suggested by CWC under flood estimations report for SONE SUB ZONE – 1(d) August 1987 will be used for preparations of synthetic unit hydrograph for the catchment area of Hurdul Nala Watershed which is Diverted nala trenching mine runoff. Procedure is explained in following step wise.

Step – 1:

Preparations of catchment area plan of Hurdul Nadi (**Figure 7.2).**

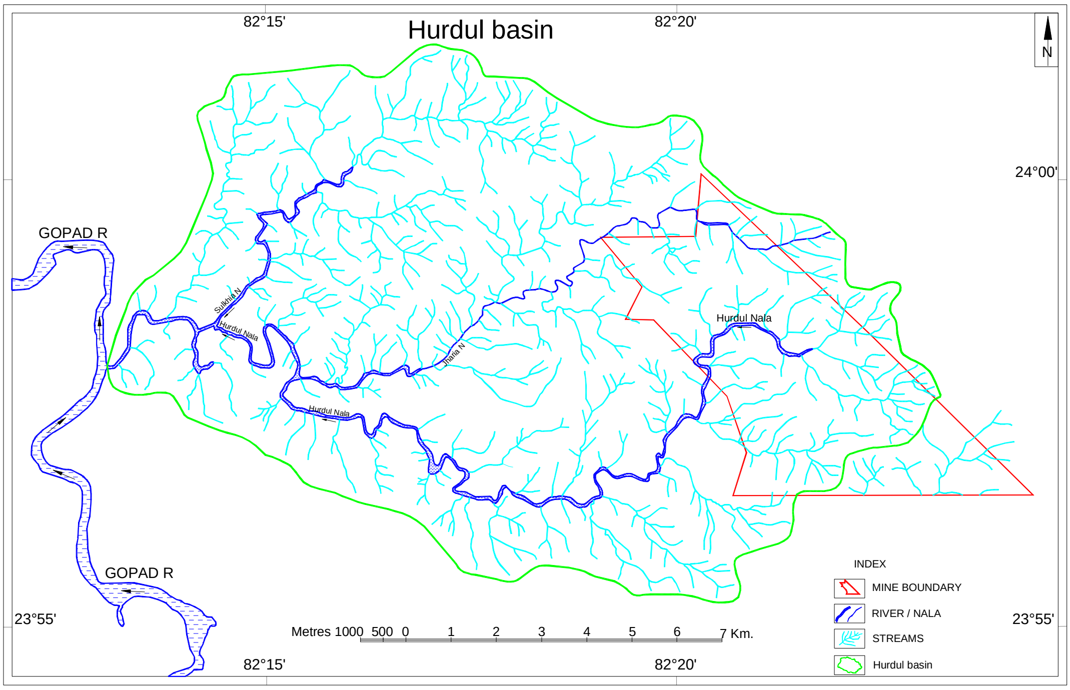


Figure 7.2: Catchment Area Plan

Step – 2:

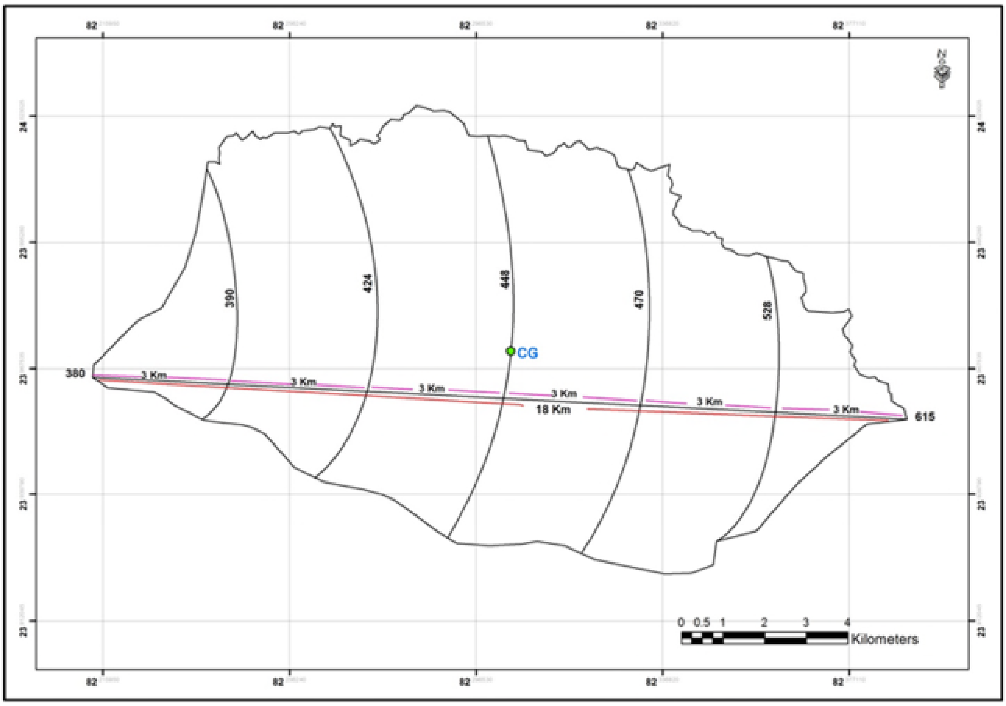
Determination of Physiographic Parameters, The following physiographic parameters were determined from the catchment area plan.

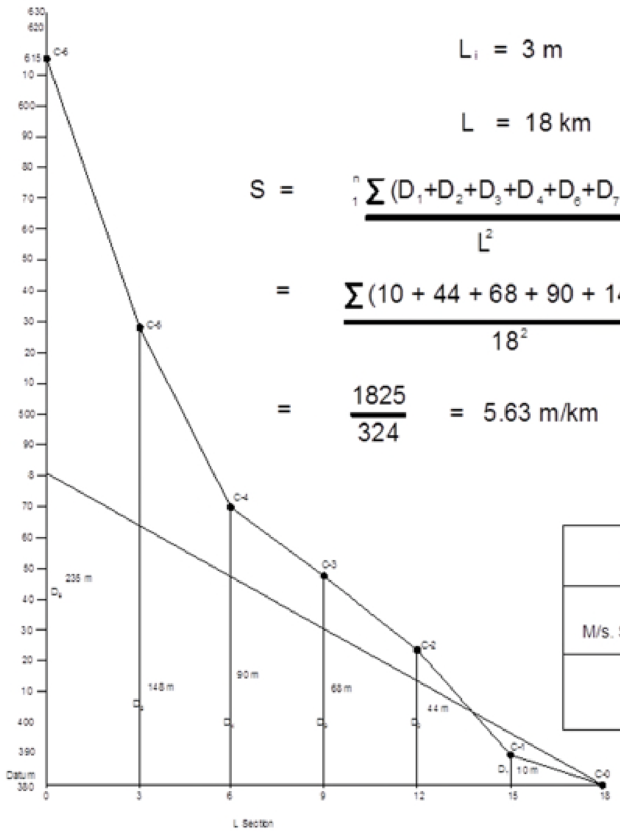
1. Area (A) : 134 km^2
2. Length of the longest stream : 18 km
3. Equivalent Stream Slope : $\frac{(615-380)}{18} = \frac{235}{18} = 13.05\ \mathrm{m/km}^2$

(a) By Graphical Method:

Longitudinal sections of the longest main stream from contours crossing the stream and the spot level along banks of nala at gauging point.

Hurdul Catchment L Section





$$L_i = 3 \text{ m}$$

$$L = 18 \text{ km}$$

$$S = \frac{\sum_1^n (D_1+D_2+D_3+D_4+D_6+D_7)\, L_i}{L^2}$$

$$= \frac{\sum (10 + 44 + 68 + 90 + 148 + 235)\, 3}{18^2}$$

$$= \frac{1825}{324} = 5.63 \text{ m/km}$$

Prepared by Srushti Seva Private Limited, Nagpur
Project Proponent M/s. Stratatech Mineral Resources Private Limited
Dhirauli Coal Block Dist Singrauli, Madhya Pradesh.

Step – 3:

Determination of Synthetic 1 hour unit Hydrograph Parameter:

The following equation were used to compute the unit hydrograph parameters with the known A, L and S value

A = 134 km^2

L = 18 km

S = 5.63 m/km

I. t_p = $0.314\ (\frac{L}{\sqrt{S}})^{1.012}$ = $0.314\ (\frac{18}{\sqrt{5.63}})^{1.012}$

= $0.314\ (7.586)^{1.012}$ = 2.44 hour rounded off to 2.5 hr.

II. q_p = $\frac{1.664}{(t_p)^{0.965}}$ = $\frac{1.664}{(2.5)^{0.965}}$

= 0.687 $m^3/sec/km^2$

III. W_{50} = $\frac{2.534}{(0.687)^{0.976}}$ = 3.6 hr say 4 hr

IV. W_{75} = $\frac{1.478}{(0.687)^{0.860}}$ = 2.04 hr say 2 hr

V. W_{R50} = $\frac{1.091}{(0.687)^{0.750}}$ = 1.45 hr say 2 hr

VI. W_{R75} = $\frac{0.672}{(0.687)^{0.719}}$ = 0.88 hr say 1 hr

VII. T_B = $5.526\ (t_p)^{0.866}$ = $5.526\ (2.5)^{0.866}$

= 12.2 hr say 12 hr

VIII. T_m = $t_p + t_r/2$ = 2.5 x ½

= 3 hr

IX. Q_P = q_p x A = 0.687 x 134

= 92.06 m^3/sec

X. $\sum^{Q}$ = $\frac{A\ x\ d}{t_r\ x\ 0.36}$ = $\frac{134\ x\ 1}{1\ x\ 0.36}$

= 372.2 m^3/sec

XI. d = 1.00 cm

Step – 4:

Drawing of Synthetic unit Hydrograph:

Estimated parameters of unit graph in step – 3 were plotted to scale on a graph paper as shown in **Figure 7.3.** The plotted points were joined to draw synthetic unit graph at $t_i = t_r$ = 1 hr interval were summed up i.e. $\sum a_i t_r$ = 372.06 m^3/sec as shown in figure and compared with the volume of 1 cm direct runoff depth over catchment with formula.

Where,

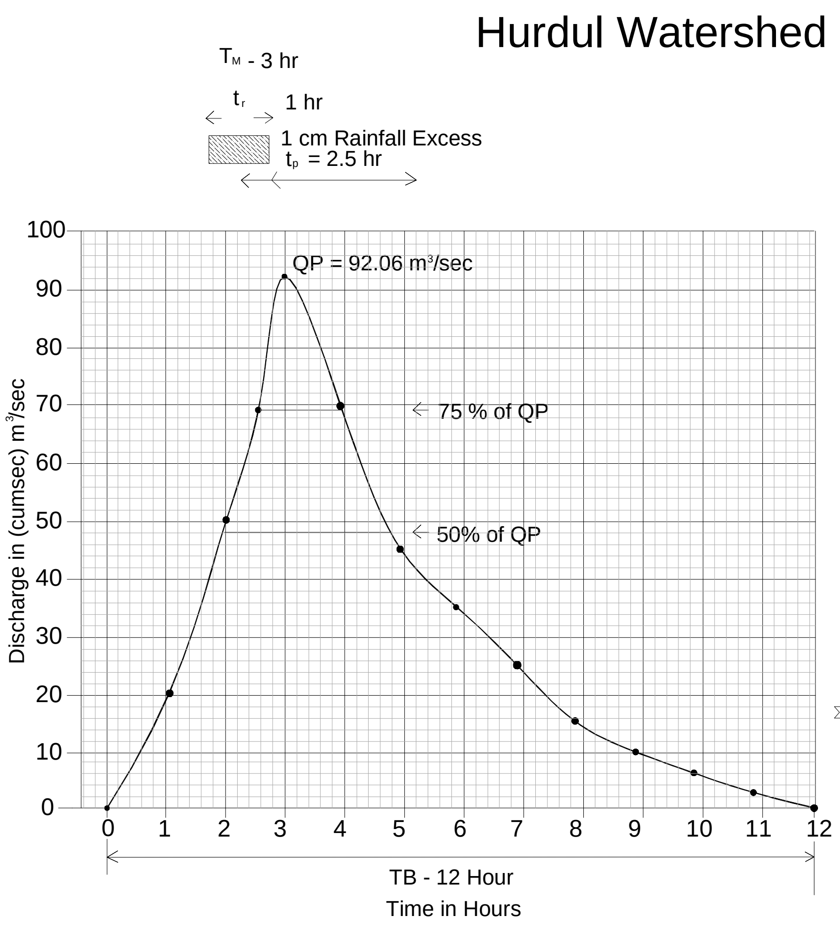
A = catchment area in km^2

d = 1.0 cm depth

t_i = t_r (the unit duration of the UG) = 1.00 hr

$Q_i = \frac{A\ x\ d}{0.36\ x\ t_r} = \frac{134\ x\ 1}{0.36\ x\ 1} =$ 372.2 m^3/sec

Thus the unit hydrograph so drawn is found to be in order.



Synthetic UG Parameter	
CA	134 km^2
t_P	2.5 hr
T_B	12 hr
Q_P	92.06 m^3/sec
W_{50}	3.6 hr
W_{75}	2.04 hr
W_{R50}	1.45 hr
W_{R75}	0.88 hr
q_P	0.689 m^3/km^2
T_M	3 hr
d	1 cm
$\frac{L}{\sqrt{S}}$	5.63 m/km
ΣQ_p	372.2 m^3/sec

Time in Hour	1 hr Synthetic Ordinate (cumsec)
0	0
01	20
02	50
03	92.06
04	70
05	45
06	35
07	25
08	15
09	10
10	7
11	3
12	0
Total ΣQ_p	372.2 m^3/sec

$\Sigma Q_i = \frac{A\ x\ d}{0.36\ x\ t_r}$

$= \frac{134\ x\ 1}{1\ x\ 0.36}$

= 372.2 cumecs

Prepared by Srushti Seva Private Limited, Nagpur
Project Proponent M/s. Stratatech Mineral Resources Private Limited
Dhirauli Coal Block Dist Singrauli, Madhya Pradesh.

Figure 7.3: Drawing of Synthetic unit Hydrograph

Step – 5:

Estimation of Design Storm Duration:

The design storm duration (T_D) = 1.1 x t_p = 1.1 x 2.5 = 2.75 hrs. Adjusting the design storm duration to the nearest one hour, the adopted design storm duration T_D is 3.0 hr.

T_D = 3 hr

Step – 6:

Estimation of Point Rainfall and Area Rainfall:

The catchment under study, Hurdul Watershed, was located on Isopluvial Map of sone 1(d) 50 year, 24 hour point rainfall. The isopluvial map is placed at **Figure 7.4 (Annexure- 1B).**

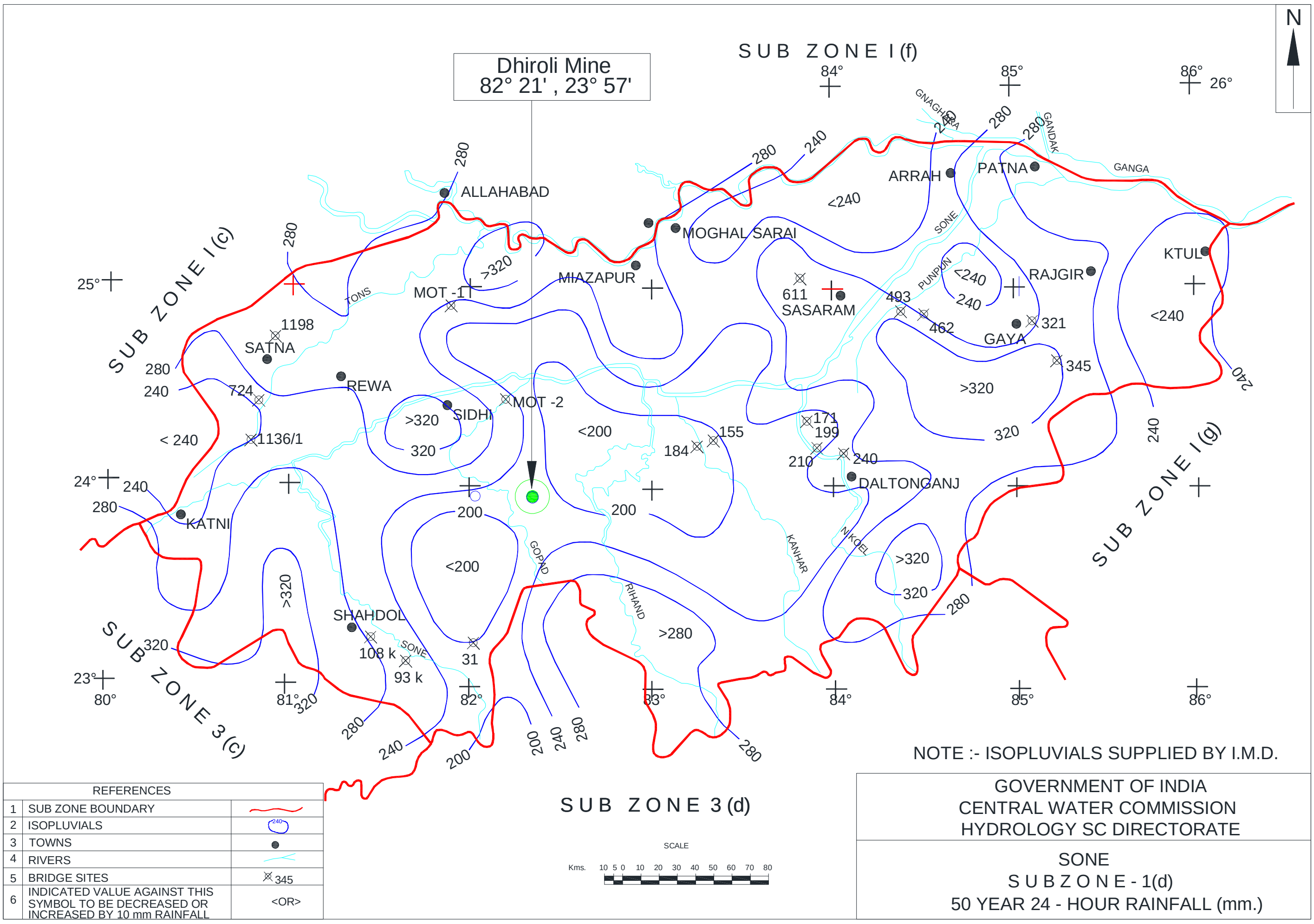


Figure 7.4: Isopluvial Map

- From the map data of 50 years point rainfall over Hurdul Watershed is recorded as 20 cm. conversion factor 0.54 was read for T_D = 3 hr following CWC table for sone sub zone (1d) **(Annexure- 1C).** The point rainfall in 50 year return period for T_D = 3 hr will be as follow.

Point rainfall = 20 x 0.54 = 10.8 cm

Areal reduction factor of 0.77 corresponding to a catchment area of 134 km^2 for T_D = 3 hour was interpolated from Table 6 of Figure 11 (a) **(Annexure- 1D).** in sections for conversion of point to areal rainfall 50 year 3 hours areal rainfall = 10.8 x 0.77 = 8.316 cm.

Point Rainfall = 10.8 cm
Areal Rainfall = 8.3 cm

Step – 7:

Time Distribution of Areal Rainfall:

50 year 3 hr areal rainfall = 8.316 cm was distributed with the distribution coefficient (COI[6] of Table A-2) **(Annexure- 1E).** or from mean average time distribution curve for storm of 3 hours to gef 1 hour rainfall increments a follows.

Table 7.3: Time Distribution of Areal Rainfall

Duration	Distribution of Coefficient	Storm Rainfall	1 hour Rainfall Increments
(hr)		cm	cm
1	**2**	**3**	**4**
1	0.7	5.81	5.81
2	0.9	7.48	1.67
3	1.0	8.32	0.84

Step – 8:

Estimation of Effective Rainfall Units:

Design loss of 0.25 cm / hr under sections has been adopted as per CWC norm for sone (1d) sub zone page 5 as **Annexure- 1F.** The following table shows the computations of 1 hr effective rainfall.

Duration	1 Hr. Rainfall	Design Loss Rate cm/hr	1 hr Effective Rainfall
hr	Cm	cm/hr	cm
1	**2**	**3**	**4 (2-3)**
1	5.81	0.25	5.56
2	1.67	0.25	1.42
3	0.84	0.25	0.59
Note	From Step 7	-	-

Step – 9:

Estimation of 50 Year Flood (Peak Only)

For estimations of the peak discharge the effective rainfall units were rearranged aainst ordinate such that the maximum effective rainfall was placed against the maximum UG ordinate and soon as shown in COL (2) & COL (3) in the following table. Summation of the product of unit graph ordinate and rainfall gives the total direct runoff as under.

Time	UG Ordinate (m^3/sec)	1 hr Effective Rainfall (cm)	Direct Runoff m^3/sec
(1)	(2)	(3)	(4)
1	20	0.59	11.80
2	50	1.42	71.10
3	92	5.56	511.52
4	70	1.42	99.40
5	45	0.59	26.55
6	35	0.59	20.65
			741.02

Baseflow is considered as arbitrary selections of baseflow being last leg of unit hydrograph and effective rainfall is 0.59 cm. thus, the bseflow may be 10 x 0.59 = 5.9 m^3/sec.

Base flow = 6 m^3/sec

Step – 10:

Compilations of Design Flood Hydrograph:

The direct runoff resulting from each of 1 hr effective rainfall units was obtained by multiplying the 1 hr effective rainfall with synthetic 1 hr UG ordinate. The base flow is added to direct runoff and flood runoff is estimated. The peak flood runoff for Hurdul Watershed, based on 50 year return period of 24 hrs rainfall has been done based on table A-3 CWC sub zone1 (d) **(Annexure- 1G).** is estimated 702.4 m^3/sec. The detailed estimation is given in **Table 7.4** and depicted in **Figure 7.5.**

50 year return period peak runoff Hurdul Watershed – 702 m^3/sec

Table 7.4: Compilations of Design Flood Hydrograph

Time in Hr	1Hr Synthetic Unit Hydrograph m^3/sec	Effective Rainfall Unit (Cm)/ Direct Runoff m3					Total Direct Runoff m^3/sec	Base flow m3/sec	Flood m3/sec	Remark
		0.59	1.42	5.56	1.42	1.59				
0	0	0.0	0.0				0.0	6.0	6.0	
1	20	11.8	0.0				11.8	6.0	17.8	
2	50	29.5	71.0	0.0			100.5	6.0	106.5	
3	92	54.3	130.6	511.5	0.0		696.4	6.0	702.4	Peak
4	70	41.3	99.4	389.2	99.4	0.0	629.3	6.0	635.3	
5	45	26.6	63.9	250.2	63.9	71.6	476.1	6.0	482.1	
6	35	20.7	49.7	194.6	49.7	55.7	370.3	6.0	376.3	
7	25	14.8	35.5	139.0	35.5	39.8	264.5	6.0	270.5	
8	15	8.9	21.3	83.4	21.3	23.9	158.7	6.0	164.7	
9	10	5.9	14.2	55.6	14.2	15.9	105.8	6.0	111.8	
10	7	4.1	9.9	38.9	9.9	11.1	74.1	6.0	80.1	
11	3	1.8	4.3	16.7	4.3	4.8	31.7	6.0	37.7	
12	0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	6.0	

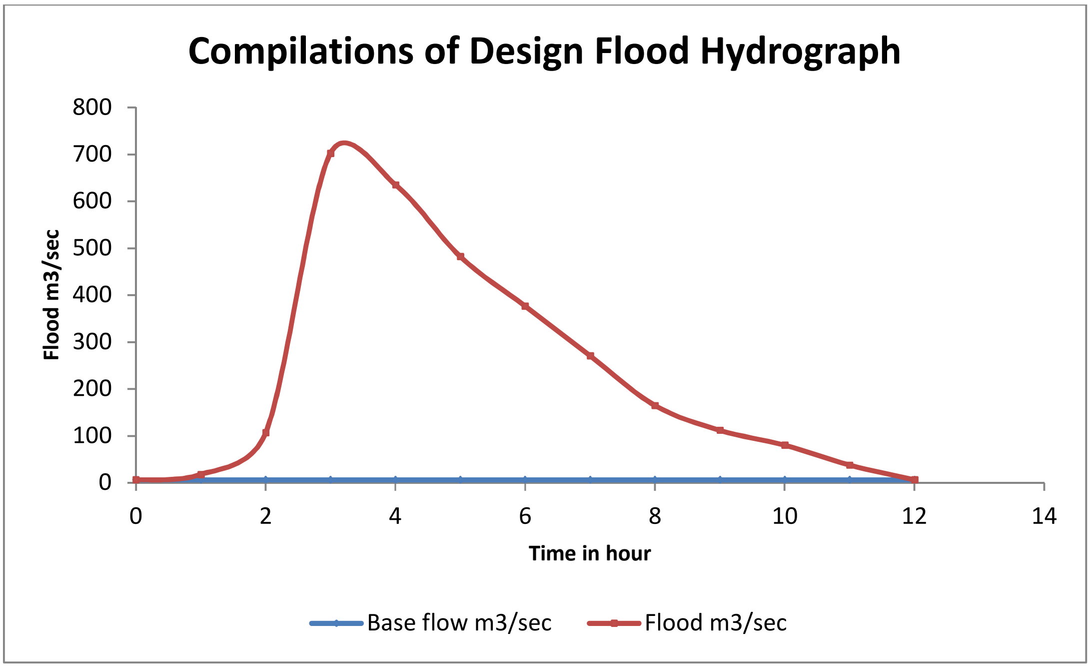


Figure 7.5: Compilations of Design Flood Hydrograph with base flow

Validation of Model:

The mathematical model developed for catchment area of 134 km^2 for 200 mm rainfall of 50 years return period. A proto model has been developed for catchment area of 11 km^2 for current maximum rainfall of 123 mm in 24 hrs. The proto model is validated with actual stream gauging measurement data in Dhirauli Coal Block having 11 km^2 catchment area and 123 mm rainfall on 19th August 2021. The peak flood occurring for 12 hrs in respect of proto model and actual measurement is given in **Table 7.5.** The same is use for preparation of hydrograph for 21 hrs and correlation graph. The hydrograph and correlation graph is given in **Figure 7.6 & Figure 7.7** respectively. The correlation coefficient R^2=0.9944. The model is validated for use in Hurdul Nala Watershed.

Table 7.5: Validation of Proto Model & Actual Measure Peak Flood (CA - 11 km^2)

Time in Hours	Peak runoff Hurdul Nala catchment 134 km2		Peak runoff in mine catchment 11 km^2 of gauging station rainfall 12.3 cm in 24 hrs		Variation in model and actual (+ -)
	model for 20 cm rainfall in 24 hrs	Proto mdel for 12.3 cm rainfall	As per proto Model	As per Actual measurement	
0	0	0	0	0.242	-0.24
1	11.8	7.257	0.596	0.426	0.17
2	100.5	61.8075	5.074	4.92	0.15
3	696.4	428.286	35.158	35.82	-0.66
4	629.3	387.0195	31.77	32.68	-0.91
5	476.1	292.8015	24.036	26.42	-2.38
6	370.3	227.7345	18.695	20.56	-1.87
7	264.5	162.6675	13.353	11.73	1.62
8	158.7	97.6005	8.012	9.1	-1.09
9	105.8	65.067	5.341	6.24	-0.9
10	74.1	45.5715	3.741	2.98	0.76
11	31.7	19.4955	1.6	1.56	0.04
12	0	0	0	0.5	-0.5

Correlation Coefficient:

$y = 1.0367x + 0.0302$

$R^2 = 0.9944$

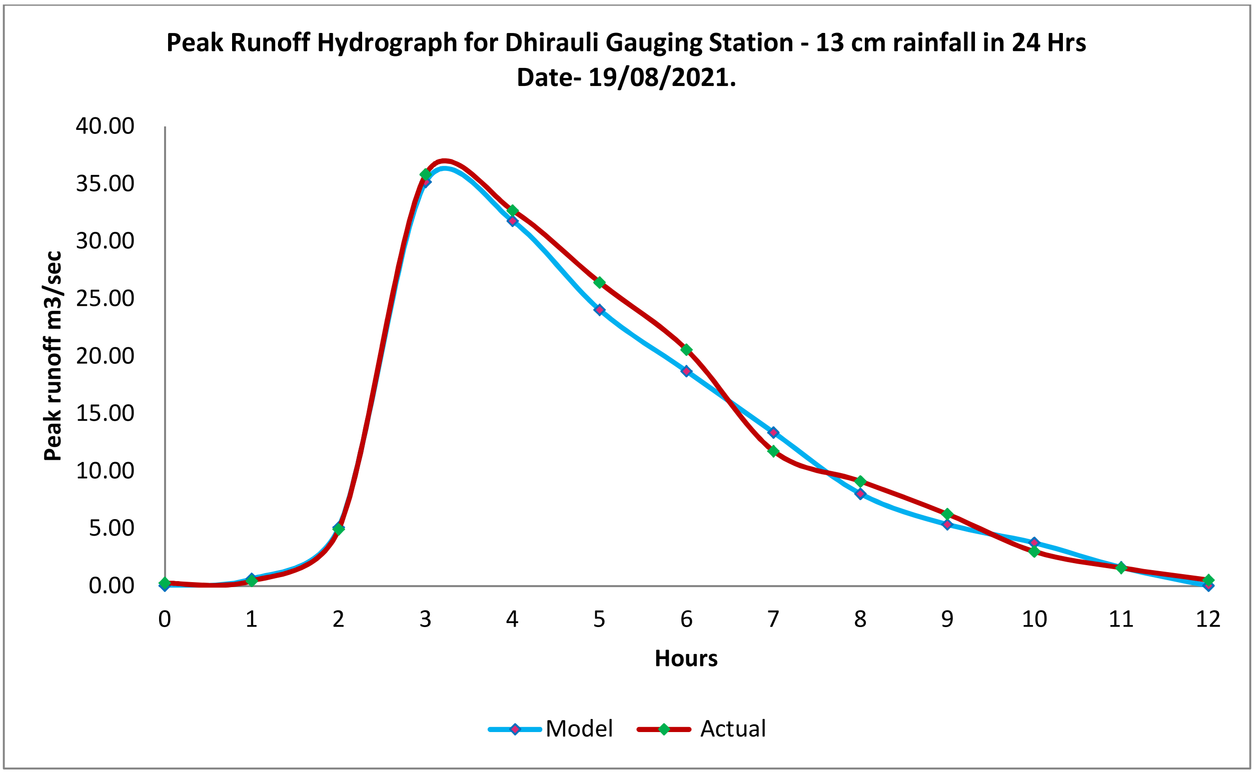


Figure 7.6: Peak Runoff Hydrograph for Dhirauli Gauging Station

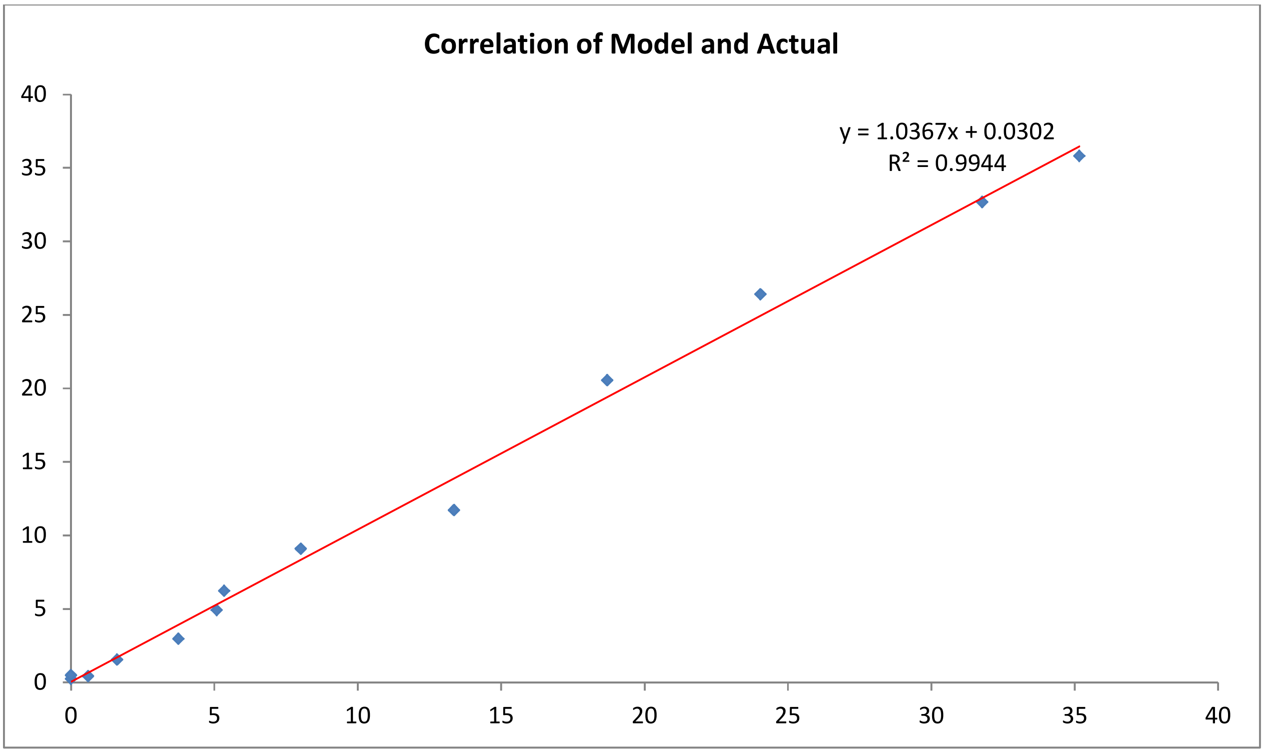


Figure 7.7: Correlation of Model and Actual

7.5 Empirical Methods for Flood Estimation:

There are various empirical methods developed for peak flood estimation. In the mine area the most popular formula applied for flood estimation in Govt. of Madhya Pradesh & Chhattisgarh is given below.

1. Dicken's Method
2. Rational Method

7.5.1 Dicken's Method:

Peak flood estimation of Hurdul Nala watershed has been estimated based on Dicken's formula.

$$QP = CA^{3/4}$$

$$QP = 19.60\ x\ (134)^{3/4}$$

= 771.94 cumec (m^3/sec)

= 772 (m^3/sec)

Where,

C = Dicken's constant depending upon catchment site, rainfall intensity as per clause 3.2 of T.C. The value of C = 19.60 (Government of Chhattisgarh)

A = Catchment area of Hurdul = 134 km^2

Dicken's Method- 772 m^3/sec

7.5.2 Rational Method:

This is most popular method for peak flood estimation of watershed. The formula for Rational Method is as under.

$$QP = \frac{CIA}{3600}$$

$$QP = \frac{0.287\ x\ 0.074\ x\ 134\ x\ 10^6}{3600}$$

$$QP = 688.6\ cumec\ m^3/sec$$

≈ 790 m^3/sec

Rational Method- 790 m^3/sec

7.6 Summary of Peak Runoff of Hurdul Watershed:

The peak runoff of Hurdul Watershed having area of 134 km^2 has been estimated by three most popular methods. The estimated value is placed for consideration in **Table 7.6.**

Table 7.6: Peak Runoff of Hurdul Watershed

Sr. No.	Method	Catchment Area (km^2)	Peak Flood Runoff (m^3/sec)	Remark
1	Unit Hydrogrpah CWC	134	702	Method adopted by CWC considered
2	Dicken's	134	772	
3	Rational	134	790	
4	**Average**	**134**	**755**	

There is almost similarity in all methods but method adopted by CWC in flood estimation report for sone sub zone 1(d) is most scientifically sound hence, value 702 m^3/sec is considered for catchment area of 134 km^2 of Hurdul Nala watershed which include Dhirauli Coal Block also. The unit peak flood runoff of 50 year return period will be 5.24 m^3/sec per km^2 catchment area. The catchment area of the external watershed is 6.70 km^2. The peak flood due to external watershed on eastern boundary will be 35 m^3/sec.

Peak Flood Runoff of Mine External Watershed = 35 m^3/sec

Design Safe Flood runoff (2.5 times) = 88 m^3/sec

This prorate peak flood runoff will be used for design of Nala Diversion Trench in Dhirauli Coal Block.

7.7 Surface Runoff Yield - Availability of Water in Hurdul Nala:

The total quantity of surface water that can be expected in a given period from a stream at the outlet of its catchment is known as yield of the catchment in that period. Water year is from the period of June to September as monsoon rainfall. The rainfall – runoff relationship for Hurdul Nala watershed having catchment area of 134 km^2 have been was estimated by surface water modeling. The rainfall – runoff relationship from climate water balance is placed P= AE +R $\underline{+}\Delta$S

P= 814 +525 -197

R_c=328 mm against annual rainfall of 1142 mm. The runoff coefficient is 0.287

Rc = 0.287

In Hurdul nala watershed the runoff coefficient is 0.287 of normal annual rainfall. The normal annual rainfall is 1.142 m. the point runoff yield will be

1.142 x 0.287= 0.327754 m/y constant for Hurdul catchment.

1. **Hurdul Catchment Area:**

The total yield during monsoon period (my) from Hurdul Naa to Gopad river is estimated as

R = A x 0.327752

R_Y = $134 \times 10^6 \times 0.327752$

= 43919036 m^3/year

≈ 43.92 MCM/year

A = Hurdul Nala Catchment Area

= 134×10^6

R_Y = Annual runoff yield m^3/year

2. **External Catchment Area to Mine:**

External Area = $6.70 \times 10^6 \times 0.327752$

= 2.19595×10^6

≈ 2.20×10^6 m^3/year

3. **Mine Catchment Area:**

Mine Area = 26.72×10^6 m^2

Runoff yield into mine area = $26.72 \times 10^6 \times 0.327752$

= 8.7575 monsoon year

≈ 8.76×10^6 m^3/year

4. **Total Mine & External Area:**

The runoff yield exit from mine through Hurdul Nala

= $(2.20+ 8.76) \times 10^6$ m^3/year

= 10.96×10^6 m^3/year

It is estimated that almost 25% of total Hurdul Watershed runoff is being contributed by Dhirauli Coal Block Watershed.

7.8 Study of Availability of Water in Hurdul Nala:

Perennial Nala- Hurdul:

Availability of water in Hurdul catchment area (134 km^2)

The availability of water in total Hurdul Nala confluence into Gopad River is studied and it is recorded as under.

1. Perennial - It is estimated that peak baseflow during monsoon is 6 m^3/sec for Hurdul nala watershed having 134 km^2. During field investigation in non-monsoon period, it is observed that about 10% area of watershed having higher order of streamlets are yielding base flow. Thus, it is recorded that non monsoon base flow at confluence point of Hurdul nala into Gopad River will be limited to 0.6 m^3/sec. The Hurdul Nala has average base flow of 0.6 m^3/sec through October to May (243 days)

   The total base flow which causes Hurdul Nala perennial is estimated as under.

   1. No. of Days = 243
   2. Average Baseflow = 0.6 m^3/sec
   3. Total baseflow over 243 days

      = 243 x 24 x 3600 x 0.6

      = 12597120 m^3/non monsoon year

      ≈ 12.60 MCM/year (non-monsoon)

The total water availability of Hurdul Nala in monsoon seasonal period is estimated earlier as 31.32 MCM/monsoon year (Total 43.92 – Non monsoon period 12.60 = 31.32). The total runoff yield of Hurdul Nala is **Table 8.3.**

1	Monsoon Period	31.32 MCM
2	Non Monsoon Period	12.60 MCM
3	Total Perennial Yield	43.92 MCM/year

7.9 Seasonal Nala- Mine Area

Mine area part of Hurdul Nala catchment area (33 km^2). The mine area part of Hurdul Nala is Seasonal Nala. This may be due to area occupied by Dhirauli Mine is in ridge area of Hurdul Watershed. The water table is deep enough that nala seepages are not noticed in non-monsoon period. The maximum depth of nala is 4 m whereas depth of water level from surface in non-monsoon period is ranging between 6to 8 m. The contribution of baseflow (ground water runoff) is essential component of perennial nature of stream. Hence, Dhirauli Mine area of Hurdul Nala is only seasonal nala. The part of Hurdul Nala exist in the mine area is not perennial as mine area is in the ridge area of watershed. The base flow generated in downstream of Hurdul Nala at mine boundary.

Mine Part of Hurdul Nala is Seasonal

7.10 Overall Impact of Nala Diversion and its contribution to other big streams i.e. Gopad River etc.:

There is need for nala diversion in case of Dhirauli Coal Mine block. The runoff yield during monsoon will be collected at exit point of Hurdul Nala in mine boundary in sedimentary pond and allow to flow as natural Drainage density. In order to keep monsoon runoff flow sustainable pollution free, the nala training will be done through Nala Diversion Trench all along boundary of mine with trap trench and finally a collection of runoff in to sedimentation pond for arresting excess TSS (Total Suspended Solid). The clean water will be allowed to flow in natural gradient of Hurdul Nala. The downstream of Hurdul Nala possessed occupied by Suliyari OCP which has already been permitted for nala diversion along boundary.

It may be recorded that during pre-mining of Dhirauli Coal Block total runoff yield contribution to Hurdul Nala is estimated 10.96 MCM/year. During mining as depth of mining increases the mine will become natural rainwater harvesting structure and harvested water will become groundwater and the mine seepage as mine water will be pumped out either from mine sump or by advance dewatering. This groundwater in turn contributes to Nala throughout year. During mining the mine pumped out water will be discharge into upper reaches of Drainage density network which will ultimately flow into sedimentation pond after due sorting of TSS in mine water. The estimation of quantity and quality of mine seepage over mining year wise is not part of this study. This will be covered in hydrogeological study with modeling for permission from CGWA NOC.

7.11 Impact on livelihood support in its downstream and providing alternative in case of diversion:

First of all there is no need for diversion of Hurdul Nala. The impact on livelihood support within mine area can be assured that during mining period sufficient mine water will be available throughout year. The competing users will use clean mine water for their three crop irrigation and round the year growing of vegetable. It is common practice in other part of coal field. The mine water after due filtration can be used as drinking water. Most of the coal India mine colony is using only mine water for their domestic consumption as well as water supply to local Villages at nominal cost. The other advantage of Nala Diversion Trench along mine boundary which will act as canal. The competing users can tap water at higher altitude to irrigate their land by gravity in lower altitude. Thus, the livelihood of competing users will have good support from available mine water and canal water.

7.12 Rationality of nala diversion in term of coal conservation and stream restoration:

The coal is nonrenewable natural resources. It takes millions of years to convert peat into coal. It is very precious fossil fuel for power generation. One cannot afford to leave coal trapped locked into sub surface as conservation measure. Now, technology is available for maximum coal extraction as part of conservation of coal and high production of coal is necessary for the economic growth of country. Sometimes it becomes necessary to divert natural streams for mining of coal available beneath than. Keeping the hydrologic regime of the upstream and downstream of the mining area is a requisite for the environmental protections in addition to many other environmental issues. It may be recorded that some time diversions of nala become inevitable considering economic growth. The back filling of over burden with plantation will restore land and restoration of stream will start. The morphometric study suggests that in past also the formation of streams were through erosional process. The same will be applicable depending upon topography of back filled area. The natural gradient will be kept in mind in mine closure plan.

Effect on aquatic ecology (if any) and mitigation measures for the same. Study of existing aquatic environment and its management considering the diversion of Hurdul Nala:

The part of Hurdul nala in mine area is seasonal. It is not perennial. Hence, there is no aquatic environment in mine area as perennial stream flow is pre requisite for aquatic ecology. The availability of mine seepage (mine water) during non-monsoon period may be considered for aquatic ecology. The mine water may be acidic or neutral depending upon the pyrite content in coal as inorganic impurities. The data so far available from geological report, there is no pyrite occurrence in coal seam. This suggests that mine water may be natural or alkaline. As such there is no need for the study of existing aquatic environment and its management.

Mine Water Quality: The mine water study is not yet started consequently mine water is not available for analysis. The mine water quality of one of the biggest mine in Singrauli Coalfield is given in next chapter (Chapter 8.0).

8.0 MINE WATER QUALITY:

The groundwater Quality has been study based on the data collected during investigation. From the observation of data the following interpretation have been done.

- pH of groundwater was ranging from 6.8 to 7.8
- Total dissolved solids (TDS) were within the range of 172 to 600 mg/l
- The hardness values were in the range of 142 to 277 mg/l
- Calcium & magnesium were range of 38 to 258 mg/l and 11 to 26 mg/l respectively.
- Chloride in the rage of 50 to 66 mg/l
- Iron in the range of .4 to .7 mg/l
- Fluoride is below 1.0 mg/l
- Heavy metals such as arsenic borne, lead, mercury were all from below detection level. In General the groundwater of mine is well within permissible limit of BIS -10500 of 2012 and suitable for drinking & Industrial purposes subject to mine water passes through sedimentation pond and chemical treatment plan before use.

9.0 WATER MANAGEMENT:

9.1 Need for Nala Diversion trench:

The need for nala diversion trench for sustainable mining is required for following reasons.

- To avoid mine inundation from peak runoff.
- Practically water free mine will yield maximum production.
- Extraction of total coal likely to be locked.
- Coal is natural non-renewable resource which should be fully extracted with due conservation and safety for National interest.
- Better management of soil conservation by garland Diverted nala trench and soil trap pit.
- There should not be any loss of stream flow of Hurdul nala due to mining.

The design of diverted nala trench is proposed keeping the following factors-

1. Mine Plan
2. EAC observation

   "No diversion of Hurdul source stream shall be allowed and same shall be proposed in EIA study with appropriate mining method to recover coal in river catchment so that biodiversity in the area by source stream should be maintained"
3. Safety of Mine

The water management for efficient mining needs to be done in respect of external surface water and internal surface water runoff.

9.2 External Water Management:

The external surface water from the area of 6.70 km2 is entering into mine through external boundary of block.

Diversion of Hurdul nala is proposed from eastern side of block boundary (flowing northern side) which will join the Bardiya/Jharia Nala a tributary of Hurdul Nala. In this way complete external surface runoff will go into same Drainage density system. Proposed diversion is depicted in to **Figure 9.1.**

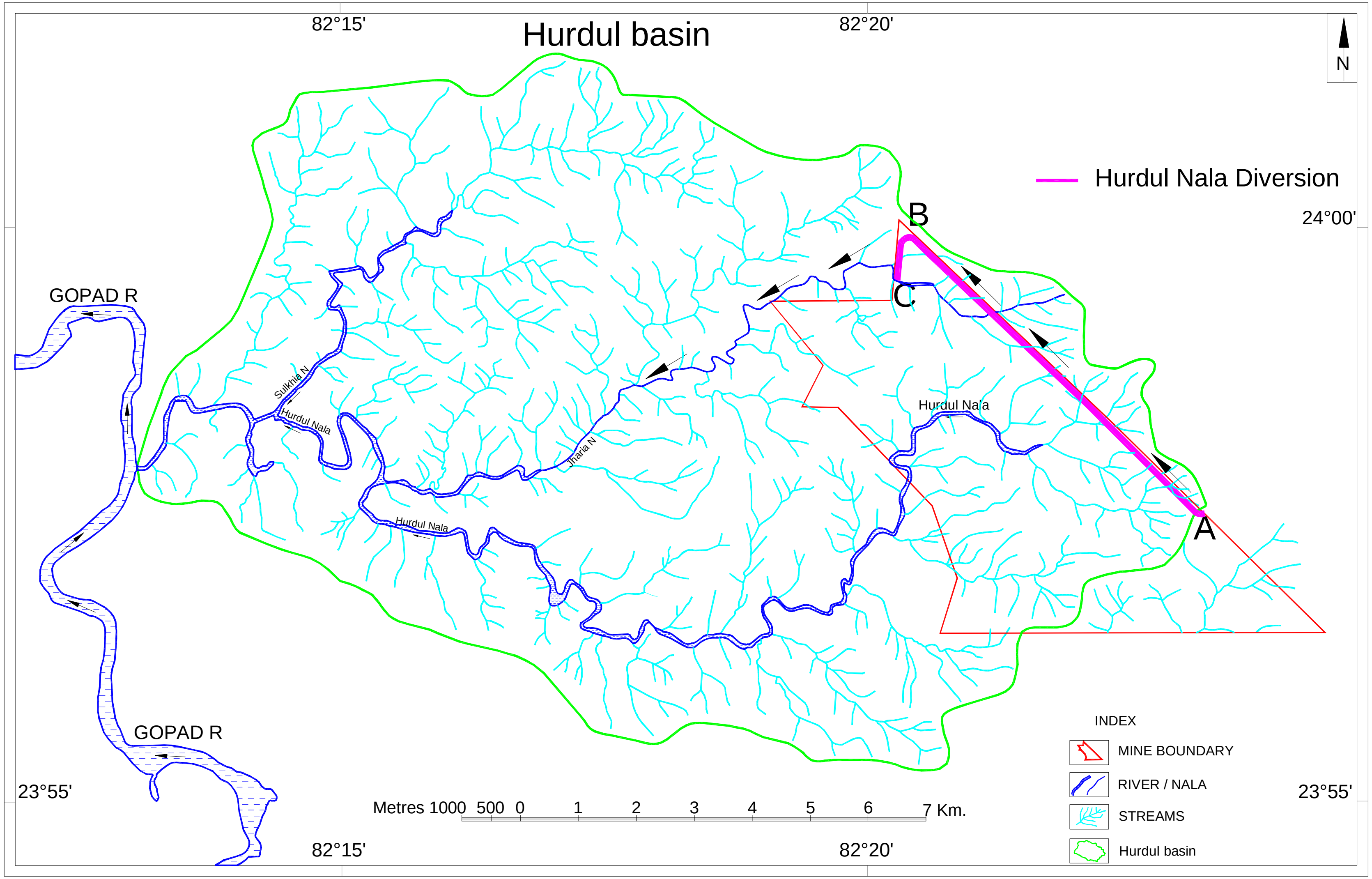


Figure 9.1: Hurdul Nala Diversion

9.2.1 Proposed Diverted Nala Trench:

The diversion of external Nala will be done along northern boundary of mine. The design is shown in **Figure 9.2.**

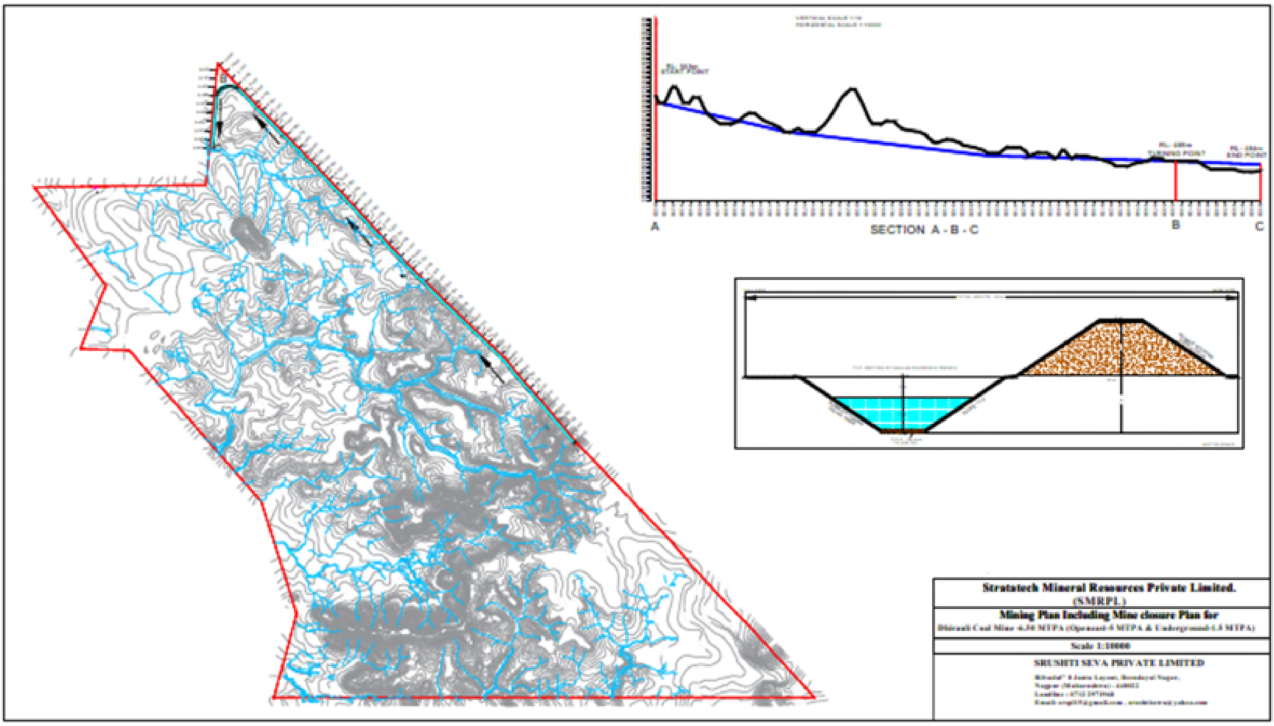


Figure 9.2: Design of Nala Diversion Trench

The diverted nala trench starts from A and end at C. The path will be as follow in **Table 9.1.**

Table 9.1: Diverted Nala Trench

Location	Length (m)	RL M amsl	Remark
A Starts	6900	555	Diverted Nala floor width- 4 m Depth- 3 m Free board- 2 m Slope 1:100
B		489	
C End		484	

The total length along boundary is 6900 m. The starting & ending RL are 555 mRL & 484 m RL respectively. The general slope will be 1:100 m. It is proposed to carry out surface excavation up to ground level along boundary side of 45 m width.

9.2.2 Design Calculation of Diverted Nala Trench:

The manning equation is commonly used to design calculation based on characteristics of channel elevation, slop, cross sectional area (A) wetted perimeter (P) Hydraulic radius (R) and Rugosity Coefficient (h) the velocity (v) of flow as per manning's equation.

$$V = \frac{1}{n} R^{2/5} S^{1/2}$$

$$QP = AV$$

QP is the peak discharge (m^3/sec) V velocity (m/sec) n is manning Rugosity coefficient, R is hydraulic gradient (m). Design capacity of velocity peak flow estimation for design for trench is given in **Table 9.2.**

Table 9.2: Design Capacities of velocity peak flow estimation for trench

Sr. No.	Details	m a msl
1	Entry Point Level	555
2	End Point Level	484
3	Net Level Difference	71
4	Length of Proposed	6900
5	Slope (s) (6900/71= 97) (1:97 say)	1:100
6	Average Water Depth	3
7	Free Board	2
8	Bottom Width	4
9	Top Width	9
10	Slop Left side	1.5:1
11	Slop Right side	1.5:1
12	Wetted perimeter	22
13	Cross sectional Area of Channel (A)	19.5
14	Hydraulic Radius (R = A/P)	0.886
15	Rugosity coefficient (n)	0.02
16	Velocity of flow as per manual Equation $V = \frac{1}{n} R^{2/5} S^{1/2} = \frac{1}{0.02} 0.886^{2/3} 0.01^{1/2}$ $= 50 \, x \, 0.952 \, x \, 0.1 = 4.76 \, m/sec$	4.76 m/sec
17	Peak flood discharge (4.76 x 19.5)	93 m^3/sec
18	Diversion of nala requirement is less than design capacity	88 m^3/sec

9.2.3 Details of external diverted Nala trench:

The details of external diverted Nala trench are given in **Table 9.3.**

Table 9.3: Details of diverted nala trench

Sr no.	Details	Data/Value	Sr no.	Details	Data/Value
1	Length of Diverted nala trench	6900 m	9	Width of Diverted nala trench	19 m
2	Width of Diverted nala trench	45 m	10	Width of berm	19 m
3	Start point of Diverted nala trench	555 m RL	11	Extra Width	7 m
4	End point of Diverted nala trench	484 mRL	12	Total Width	45 m
5	General slope of Diverted nala trench	1:100	13	Height of berm	5 m above trench
6	Width of Diverted nala trench	4 m	14	Top width of berm	4 m
7	Depth of water	3 m	15	Both side slope of Diverted nala trench and berm	1.5 H:1
8	Free board	2 m			

9.3 Internal Water Management:

There is no need for diversion of Nala within mine area. As per mine practice in open cast coal mine the garland Diverted nala trench within mine area will be constructed as and when required at suitable location to avoid surface water runoff in rush into working mine area.

10.0 COST ESTIMATION:

Cost estimation for the construction of Nala Diversion Trench

All the detailed cost estimation for Surface excavation, Surface level filling and Nala diversion trench is given in **Table 10.1, 10.2 and 10.3** and summarized cost estimation is given in **Table 10.4** and Pie chart is given in **Figure 10.1.** The detailed design of Nala Diversion Trench with Sections is given in **Annexure - 2**

Table 10.1: Surface excavation in the periphery

Surface Excavation in the Periphery of Boundary wall & width of 45 Meters											
Sl no	**Details**	**Description**	**Section**	**Unit**	**No**	**Length (m)**	**Width (m)**	**Avg Depth (m)**	**Quantity (m3)**	**Rate (Rs)**	**Amount(Rs)**
1	**Item No 18.2.1, Page 227 ISSOR 21Govt MP**	**Eartwork in excavation** for foundation, trenches for pipes /drains etc.by mechanical means/manual means(exceeding 30 cm in depth)including ramming of bottom, dressing of sides disposal of excavated earth as directed by engr in charge. **A-B-C (RL 555-489-484)**	100m - 600 m	Cum	1	500	45.00	11.704	263340.00		
			1000m - 1450m	Cum	1	450	45.00	6.885	139421.25		
			1550M - 3800 m	Cum	1	2250	45.00	16.475	1668093.75		
			3900m - 4300m	Cum	1	400	45.00	4.305	77490.00		
			4350m - 4500 m	Cum	1	150	45.00	2.45	16537.50		
			4600 m -4700m	Cum	1	100	45.00	4.71	21195.00		
			4800m - 5000m	Cum	1	200	45.00	0.96	8640.00		
			5700m - 5800m	Cum	1	100	45.00	1.48	6660.00		
		B-C	5.9m - 6.30m	Cum	1	400	45.00	0.625	11250.00		
								Total	**2212627.50**	**97.00**	**214624867.50**
2	Item no.3.34.3 , page no 40	Providing & Laying 230 mm thk Soling with Rolling & compaction over back filled area & as directed by Engineer Incharge (Qty AS sameas Filling Quantity)		Cum	1	6900	45.00	**0.23**	**71415**	**412.00**	**29422980.00**
									G Total		**244047847.50**
										Say	**244047848.00**
			Rupees Twenty Four Crore Forty Lakhs Fourty Seven Thousand Eight Hundred & Fourty Eight Only								
D- Depth, H- height											

Table 10.2: Surface Level filling

Surface Filling in the Periphery of Boundary wall & width of 45 Meters											
Sl no	Details	Description	Section	Unit	No	Length (m)	Width (m)	Avg Depth (m)	Quantity (m3)	Rate (Rs)	Amount(Rs)
1	**Item No 18.2.8 page no 228- ISSOR 21 Govt MP**	Filling in the Periphery of Boundary Wall upto the width of 45 mtr as per site requirement. **(A-B-C RL 555-484)**	600m - 1000m	Cum	1	400	45.00	4.723	85014		
			1450m - 1550m	Cum	1	100	45.00	0.78	3510		
			3800m - 3900m	Cum	1	100	45.00	1.04	4680		
			4300m -4350m	Cum	1	50	45.00	1.06	2385		
			4500m - 4600m	Cum	1	100	45.00	1.55	6975		
			4700m -4800m	Cum	1	100	45.00	0.75	3375		
			5000m -5700m	Cum	1	700	45.00	4.62	145530		
			5800m - 5900m	Cum	1	100	45.00	0.22	990		
			6300m -6900m	Cum	1	600	45.00	5.475	147825		
								Total	**400284**	**50.00**	**20014200.00**

Table 10.3: Estimate for Nala Diversion Trench

Estimate for Nallah Diversion Trench											
Sl no	Details	Desription	Unit	No	Length(m)	Cross sectional area of Trench		Quantity (m3)	Rate (Rs)	Amount(Rs)	Remark
1	**Item No 18.2.1, Page 227 ISSOR 21Govt MP**	Eartwork in excavation for foundation, trenches for pipes /drains etc.by mechanical means/manual means(exceeding 30 cm in depth)including ramming of bottom, dressing of sides disposal of excavated earth as directed by engr in charge.	cum	1	6900	**57.5**		396750	97.00	38484750.00	57.5 m2 = Cross Sectional Area of Trench
	Item No 18.2.8 page no 228- ISSOR 21 Govt MP	Filling in the Periphery of Boundary Wall upto the width of 45 mtr as per site requirement. (A-B-C RL 597-489-471) **For Berm**	cum	1	6900	**57.50**		396750	50.00	19837500.00	Cross Sectional Area of Berm = 57.5 m^2
					Length(m)	**Width (m)**	**Depth (m)**				
2	Item No 4.08.2.2Page no 48, UCSR 2017	Providing & Placing P.C.C M-15	cum	1	6900.00	4.00	0.10	2760.00	3479.00	9602040.00	
3	Item No 4.14.2, Page no 50	Providing & Constructing Stone Pitched Lined in Trench--- as directed by engineer incharge									
		For Diversion Trench	Sqmt	2	6900.00		9.00	124200.00	193.00	23970600.00	
		For Berm	Sqmt	2	6900.00		9.00	124200.00	193.00	23970600.00	
	Item no.3.34.3, page no 40	Providing & Laying 230 mm thk Soling with Rolling & compaction over back filled area & as directed by Engineer Incharge (Qty AS sameas Filling Quantity)	cum	1	6900.00	45.00	0.23	71415.00	412.00	29422980.00	
								G. Total		**145288470.00**	
		Rupees Fourteen Crore Fifty Two Lakhs Eighty Eight Thousand Four Hundred & Seventy only									

Table 10.4: Summarized Cost Estimate

Summarized Cost Estimate for Water Management at Dhirauli		
Sheet no.	**Details**	**Amount (Rs)**
1	Site Leveling - Surface Excavation	244047848.00
2	Site Leveling - Surface Filling	20014200.00
3	Nala Diversion Trench	145288470.00
	G Total	**409350518.00**
Rupees Fourty Crore Ninety Three Lakhs Fifty Thousand Five Hundred & Eighteen Only		

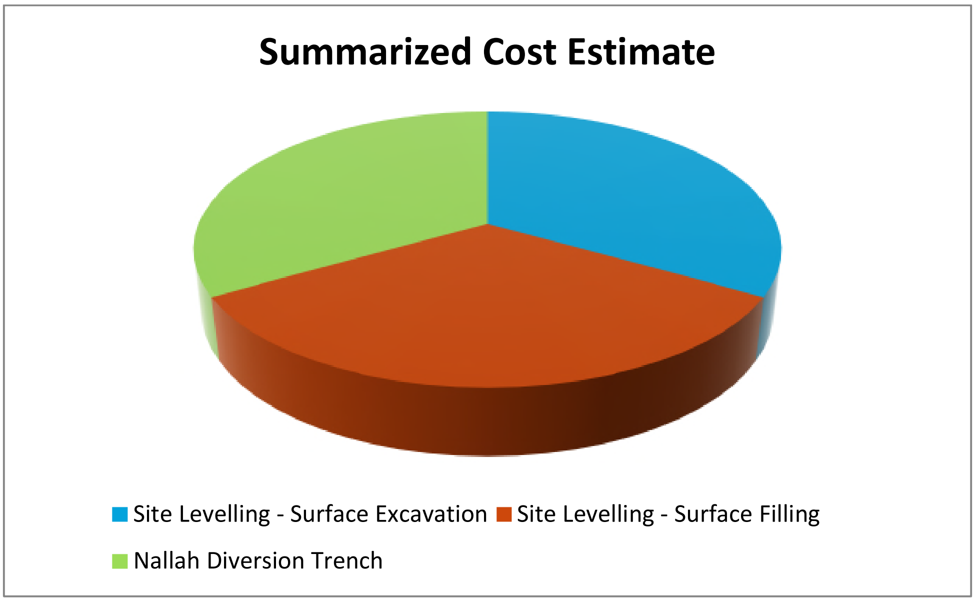


Figure 10.1: Pie Chart - Summarized Details of Cost Estimate

References

- K. Subramanya (2008) Engineering Hydrology- K. Subramanya (2008)The McGraw Hill Companies.
- V. T. Chow (1964) Handbook of Hydrology
- C. W. C (1987) Flood estimation Sone sub zone 1987 Govt. of India
- N. K. Prasad (1999) Project in charge Final technical report modeling and control of water system in coal mining environmental Chandrapur, Maharashtra. UNDP Project by UNDTCD of United National acting as executive agency.
- CWC (2001) Manual on estimation of design flood Govt. of India
- CGWB GEC (2015), Govt. of India

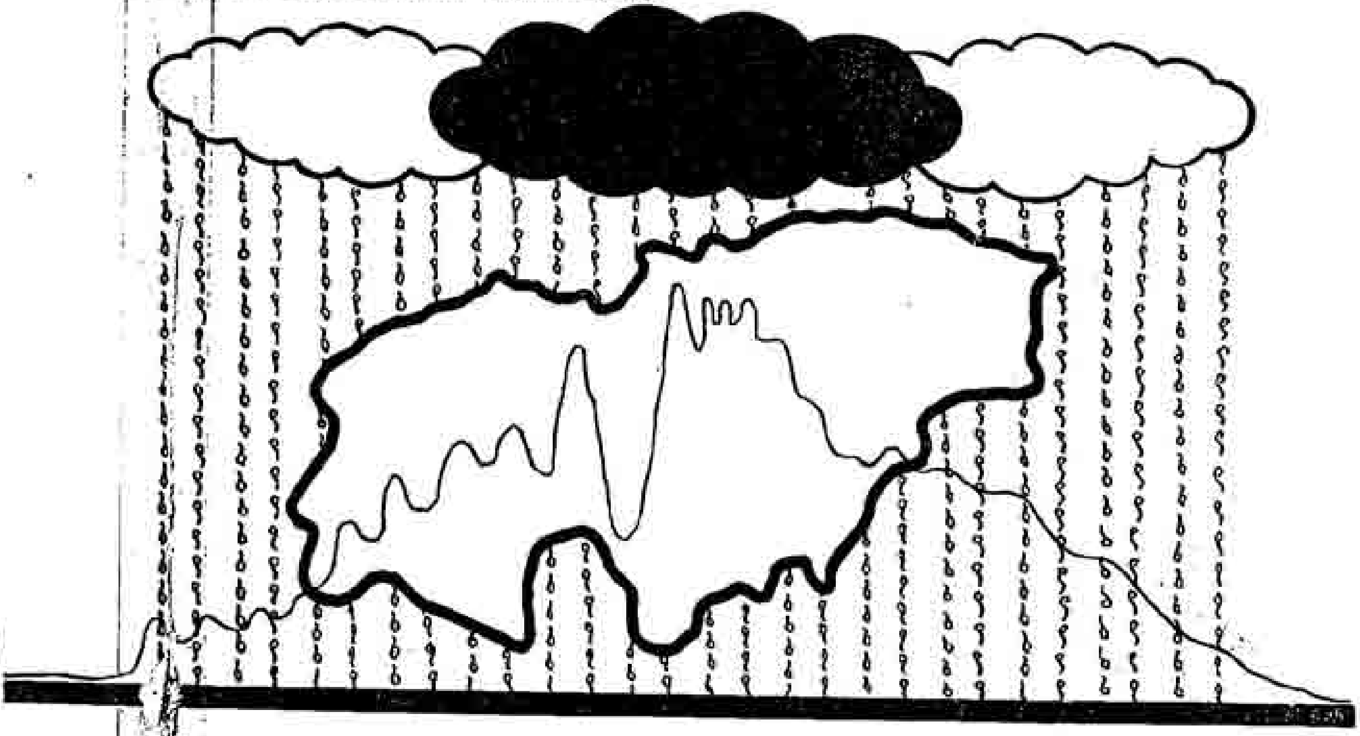
Table of Content

सोन उप क्षेत्र-१(डी) की बाढ़ आकलन का विवरण

यूनिट जलारेख सिद्धान्त पर आधारित एक प्रणाली

FLOOD ESTIMATION REPORT FOR SONE SUB ZONE-1(d)

A METHOD BASED ON UNIT HYDROGRAPH PRINCIPLE



DIRECTORATE OF HYDROLOGY
(SMALL CATCHMENTS)
CENTRAL WATER COMMISSION
NEW DELHI-110066

A JOINT WORK OF
CENTRAL WATER COMMISSION
(MIN. OF WATER RESOURCES);
RESEARCH DESIGNS & STANDARDS ORGANISATION,
MIN. OF TRANSPORT (RAILWAYS);
MIN. OF SURFACE TRANSPORT (ROADS WING),
INDIA METEOROLOGICAL DEPTT.
(DEPTT. OF SCIENCE & TECHNOLOGY)

CWC PUBLICATION NO. 33/88

FLOOD ESTIMATION REPORT FOR SONE SUBZONE - 1 (d)

A METHOD BASED ON UNIT HYDROGRAPH PRINCIPLE
DESIGN OFFICE REPORT NO. S/15/1987

HYDROLOGY (SMALL CATCHMENTS) DIRECTORATE
CENTRAL WATER COMMISSION
NEW DELHI

AUGUST 1987

Annexure 1 B

Plate 9- 50 years- 24 hour Rainfall (mm)

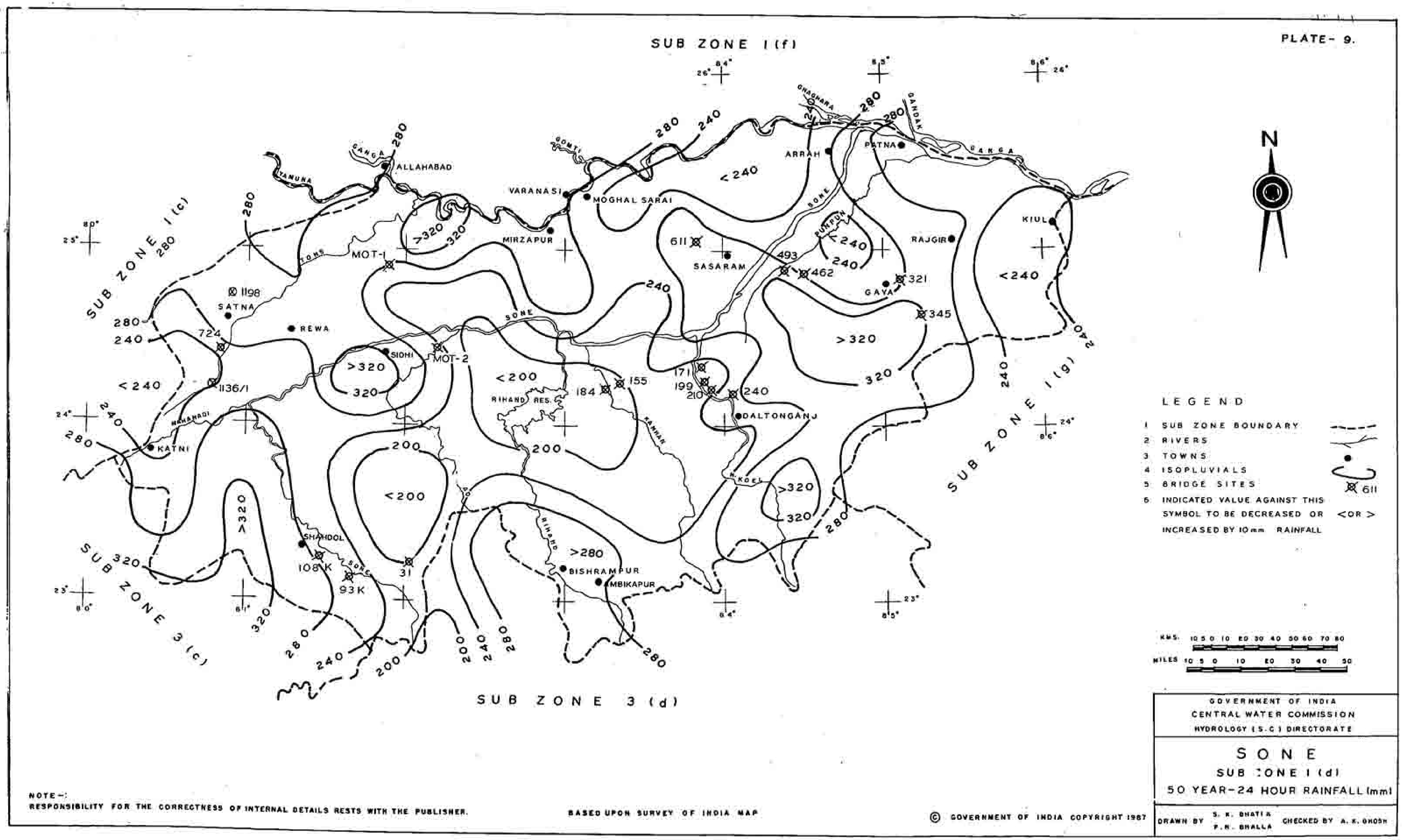
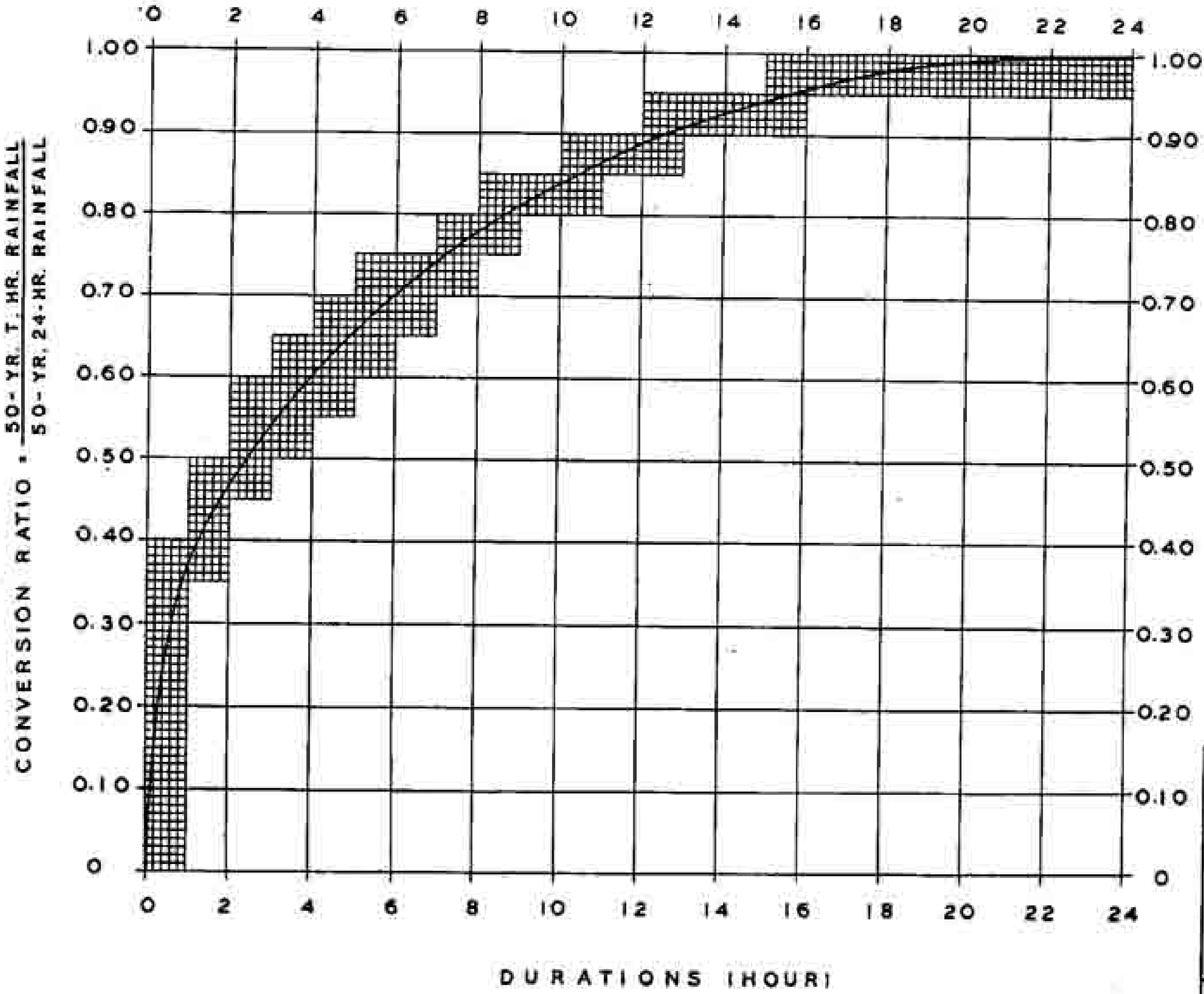


Figure 10- Sone Sub Zone 1 (d)- Duration vs. Conversion Ratio

FIG. 10



RATIOS OF 24-HR. POINT RAINFALL TO SHORT DURATION RAINFALL

DURATION (HR.)	RATIO
0	0.0
1	0.370
2	0.470
3	0.540
4	0.600
5	0.655
6	0.700
7	0.740
8	0.780
9	0.810
10	0.838
11	0.865
12	0.890
13	0.910
14	0.925
15	0.940
16	0.955
17	0.967
18	0.980
19	0.985
20	0.990
21	0.995
22	0.997
23	0.998
24	1.000

GOVERNMENT OF INDIA
CENTRAL WATER COMMISSION
HYDROLOGY (SMALL CATCHMENTS) DTE.

SONE

SUB ZONE I (d)

DURATION VS. CONVERSION RATIO

DRAWN BY. —	CHECKED BY. —
S. N. MALHOTRA L. P. NAUTIYAL	A. K. GHOSH.

Figure- 11 (a)- Areal to Point Rainfall Ratio Percentage

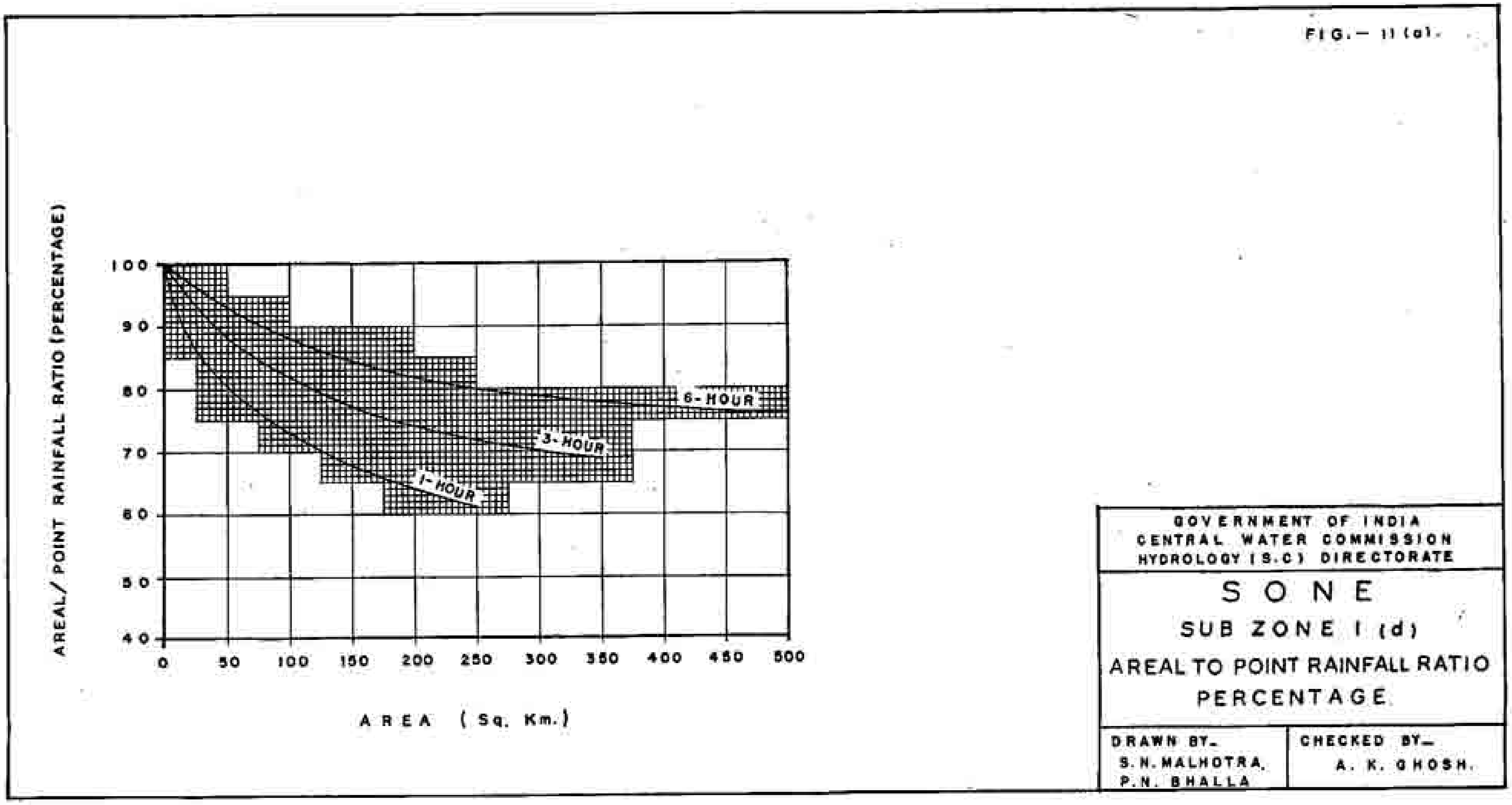


Table 1- Time Distribution Coefficient of Areal Rainfall Sone, Sub-Zone

TABLE - A-2: TIME DISTRIBUTION COEFFICIENTS OF AREAL RAINFALL SONE, SUB-ZONE 1(d)

TIME IN HOURS 1	DISTRIBUTION: COEFFICIENT FOR DESIGN STORM DURATION OF 2-24 HOURS 2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		20	21	22	23	24	TIME IN HOURS 25
24																							1.00	24
23																						1.00	0.99	23
22																					1.00	0.99	0.98	22
21																				1.00	0.99	0.98	0.96	21
20																			1.00	0.99	0.97	0.96	0.95	20
19																		1.00	0.99	0.97	0.96	0.95	0.93	19
18																	1.00	0.99	0.97	0.96	0.94	0.93	0.91	18
17																1.00	0.99	0.97	0.96	0.94	0.92	0.91	0.89	17
16															1.00	0.99	0.97	0.95	0.94	0.92	0.90	0.89	0.87	16
15														1.00	0.98	0.97	0.96	0.93	0.91	0.89	0.88	0.87	0.85	15
14													1.00	0.98	0.97	0.95	0.94	0.91	0.89	0.87	0.86	0.85	0.83	14
13												1.00	0.98	0.97	0.95	0.94	0.92	0.88	0.87	0.85	0.83	0.82	0.80	13
12											1.00	0.98	0.97	0.95	0.93	0.92	0.90	0.86	0.84	0.82	0.80	0.79	0.77	12
11										1.00	0.98	0.96	0.95	0.93	0.91	0.89	0.88	0.83	0.81	0.79	0.77	0.76	0.74	11
10									1.00	0.98	0.96	0.94	0.92	0.90	0.88	0.87	0.85	0.79	0.77	0.76	0.74	0.72	0.70	10
9								1.00	0.98	0.96	0.94	0.91	0.89	0.87	0.86	0.84	0.82	0.75	0.74	0.72	0.70	0.68	0.67	9
8							1.00	0.98	0.96	0.93	0.91	0.88	0.86	0.84	0.82	0.81	0.79	0.72	0.69	0.68	0.66	0.65	0.63	8
7						1.00	0.98	0.95	0.93	0.90	0.88	0.85	0.82	0.81	0.79	0.77	0.76	0.67	0.64	0.63	0.62	0.59	0.58	7
6					1.00	0.97	0.94	0.91	0.89	0.86	0.84	0.80	0.78	0.76	0.75	0.73	0.71	0.61	0.59	0.58	0.56	0.55	0.54	6
5				1.00	0.97	0.93	0.90	0.87	0.84	0.82	0.80	0.75	0.74	0.71	0.70	0.69	0.67	0.55	0.54	0.52	0.51	0.50	0.48	5
4			1.00	0.96	0.92	0.88	0.84	0.81	0.78	0.76	0.73	0.70	0.68	0.66	0.64	0.62	0.60	0.49	0.47	0.46	0.44	0.43	0.42	4
3		1.00	0.95	0.90	0.86	0.80	0.77	0.73	0.70	0.68	0.66	0.61	0.59	0.57	0.56	0.54	0.53	0.41	0.39	0.38	0.37	0.36	0.34	3
2	1.00	0.90	0.86	0.81	0.76	0.69	0.66	0.64	0.60.	0.57	0.56	0.49	0.47	0.45	0.44	0.43	0.42	0.30	0.30	0.27	0.27	0.27	0.26	2
1	0.83	0.72	0.69	0.64	0.59	0.50	0.46	0.43	0.40	0.37	0.34	-0.32	0.30	0.28	0.27	0.26	0.25	0.18	0.18	0.18	0.16	0.14	0.14	1

NOTE: HOURLY RAINFALL DISTRIBUTION COEFFICIENTS AREA GIVEN IN THE VERTICAL COLUMNS FOUR VARIOUS DESIGN STORM DURATIONS FROM 2-24 HOURS.

section for conversion of point to areal rainfall 50-yr 6-hr areal rainfall = 16.10 x 0.78 cm.

Note : When the catchment under study falls between two isohyets the point rainfall may be computed for the catchment taking into account the isohyets.

Step-7: Time Distribution of Areal Rainfall

50-yr 6-hr areal rainfall = 12.56 cm was distributed with the distribution coefficients (col.6 of Table A-2) or from mean average time distribution curve for storms of 4-6 hrs in Fig. 12(b) corresponding to 6-hrs to get 1-hr rainfall increments as follows:

Duration (hr)	Distribution co-efficients	Storm rainfall (cm)	1-hr. rainfall increments
(1)	(2)	(3)	(4)
1	0.58	7.28	7.28
2	0.77	9.67	2.39
3	0.85	10.68	1.01
4	0.92	11.55	0.87
5	0.97	12.18	0.63
6	1.00	12.56	0.38

Step-8: Estimation of Effective Rainfall Units

Design loss rate of 0.25 cm/hr under section has been adopted.

The following table shows the computation of 1-hr effective rainfall units in col. (4) by substracting the design loss rate in col.(3) from 1-hr rainfall increments in col. (2).

Duration (hr)	1-Hr. rainfall (cm)	Design loss Rate (cm/hr)	1-hr. effective rainfall (cm)
(1)	(2)	(3)	(4)
1	7.28	0.25	7.03
2	2.39	"	2.14
3	1.01	"	0.76
4	0.87	"	0.62
5	0.63	"	0.38
6	0.38	"	0.13

The column (2) in above table is taken from col. (4) of table in Step-7.

Annexure 1 G

Table- 2 Computation of Design Flood Hydrograph

TABLE - A - 3 COMPUTATION OF DESIGN FLOOD HYDROGRAPH

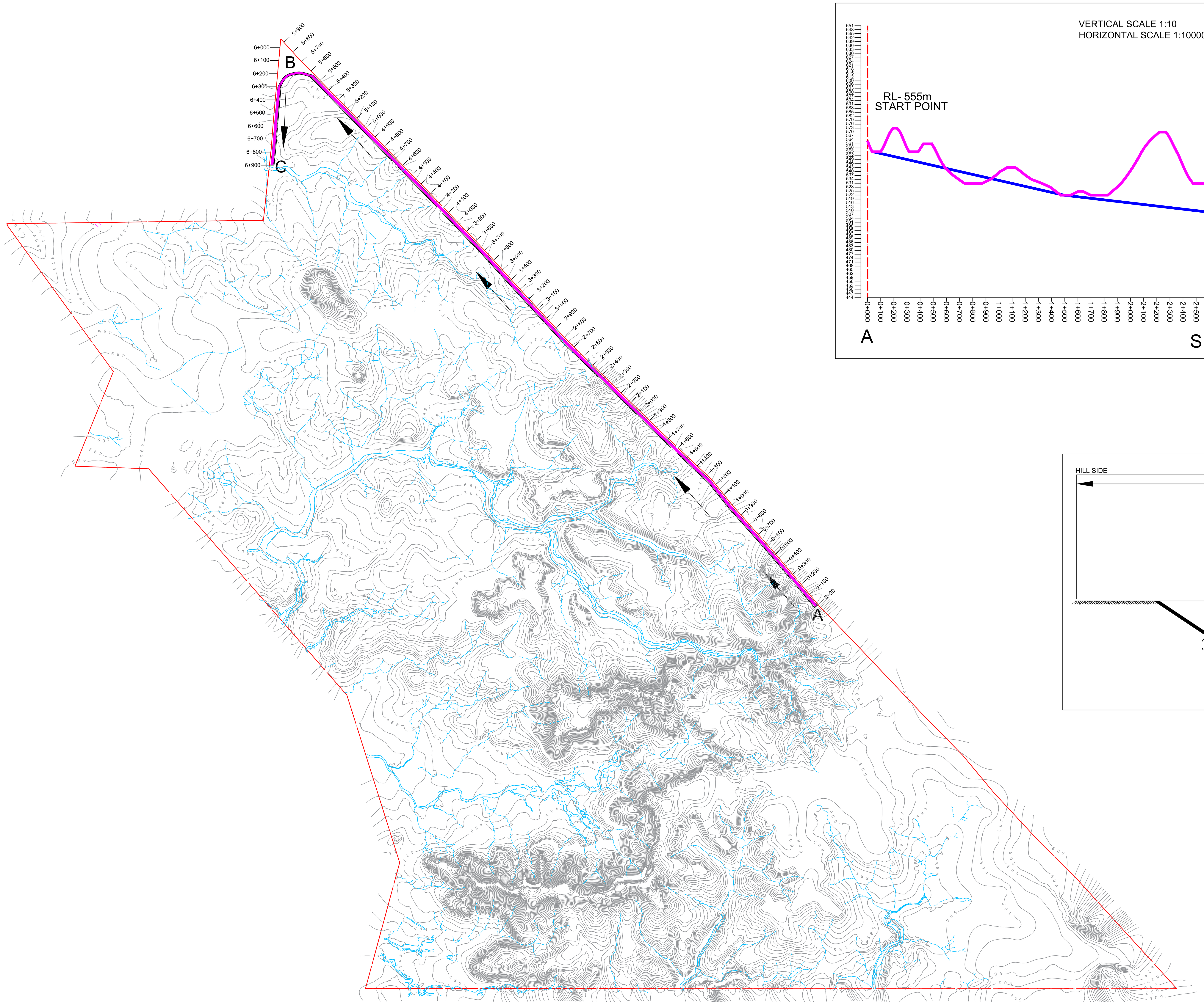
SUB-ZONE-1(d) RIVER-SIMRAWAL N.RAILWAY BRIDGE NO. 1198 CA 340.64 Km^2

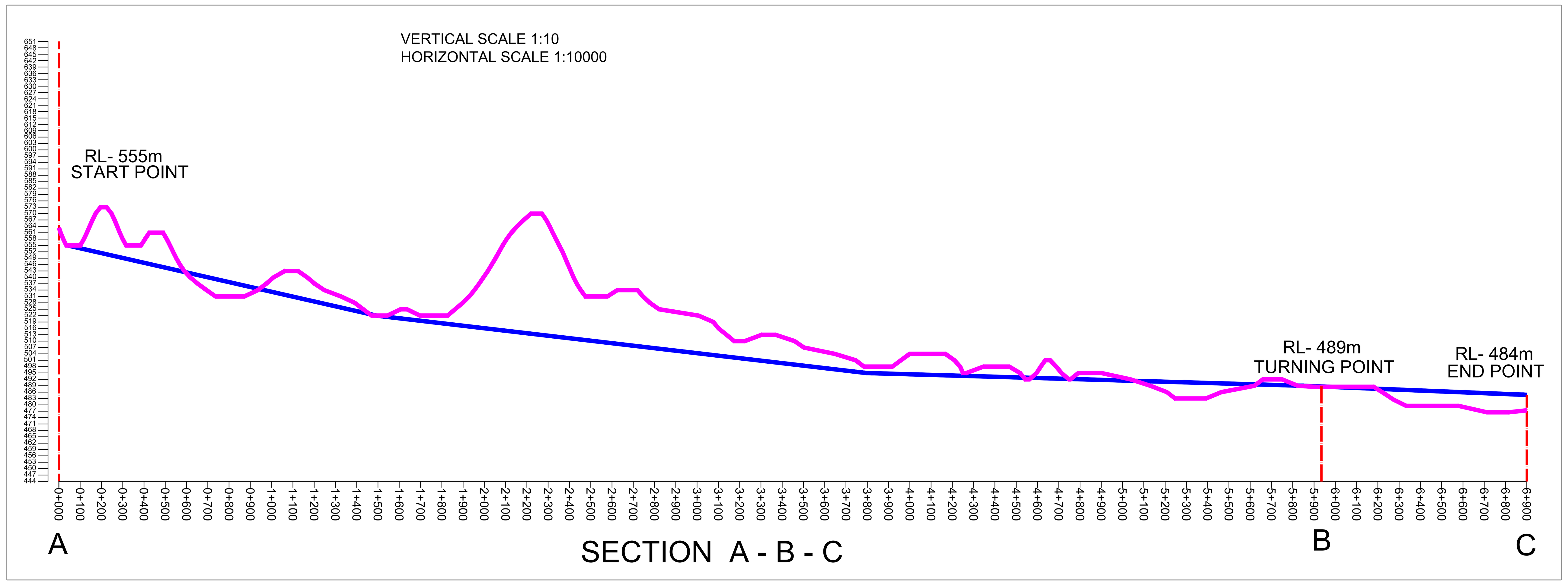
Time (Hrs)	1-hr Synthetic Unitgraph (Cumecs)	EFFECTIVE RAINFALL UNITS (CM) 0.38	0.62	2.14	7.03	0.76	0.13	Total Direct Runoff (Cumecs)	Base Flow (Cumecs)	Flood (Cumecs)	Remarks
		DIRECT RUNOFF (CUMECS)									
1	2	3	4	5	6	7	8	9	10	11	12
0	0	0						0	15.33	15.33	
1	8.0	3.04	0					3.04	15.33	18.37	
2	19.5	7.41	4.96	0				12.37	15.33	27.70	
3	37.5	14.25	12.09	17.12	0			65.75	15.33	81.08	
4	68.6	26.07	23.25	41.73	56.24	0		147.29	15.33	162.62	
5	95.0	36.10	42.53	80.25	137.08	6.08	0	302.04	15.33	317.37	
6	109.3	41.53	58.90	146.80	263.62	14.82	1.04	526.71	15.33	542.04	
7	98.0	37.24	67.77	203.30	482.26	28.50	2.53	821.60	15.33	836.93	
8	86.5	32.87	60.76	233.90	667.85	52.14	4.87	1052.39	15.33	1067.72	
9	76.0	28.88	53.63	209.72	768.37	72.20	8.93	1141.73	15.33	1157.06	Peak
10	66.0	25.08	47.12	185.11	688.94	83.07	12.35	1041.67	15.33	1057.00	
11	55.0	20.90	40.92	162.64	608.09	74.48	14.21	921.24	15.33	936.57	
12	46.0	17.48	34.10	141.24	534.28	65.74	12.74	805.58	15.33	820.91	
13	38.5	14.63	28.52	117.70	463.98	57.76	11.24	693.83	15.33	709.16	
14	31.6	12.01	23.87	98.44	386.65	50.16	9.88	581.01	15.33	596.34	
15	26.1	9.92	19.59	82.39	323.38	41.80	8.58	485.66	15.33	500.99	
16	21.5	8.17	16.18	67.62	270.65	34.96	7.15	404.73	15.33	420.06	
17	17.3	6.57	13.33	55.85	222.15	29.26	5.98	333.14	15.33	348.47	
18	14.0	5.32	10.73	46.01	183.48	24.02	5.00	274.56	15.33	289.89	
19	11.0	4.18	8.68	37.02	151.14	19.84	4.11	224.97	15.33	240.30	
20	8.6	3.27	6.82	29.96	121.62	16.34	3.39	181.40	15.33	196.73	
21	6.2	2.36	5.33	23.54	98.42	13.15	2.79	145.59	15.33	150.92	
22	4.0	1.52	3.84	18.40	77.33	10.65	2.25	113.98	15.33	129.31	
23	2.0	0.76	2.48	13.27	60.46	8.36	1.82	87.15	15.33	102.38	
24	0	0	1.24	8.56	43.59	6.54	1.43	61.36	15.33	76.69	
			0	4.28	28.12	4.71	1.12	38.23	15.33	53.56	
				0	14.06	3.04	0.81	17.91	15.33	33.24	
					0	1.52	0.52	2.04	15.33	17.37	
						0	0.26	0.26	15.33	15.59	
							0	0	15.33	15.33	

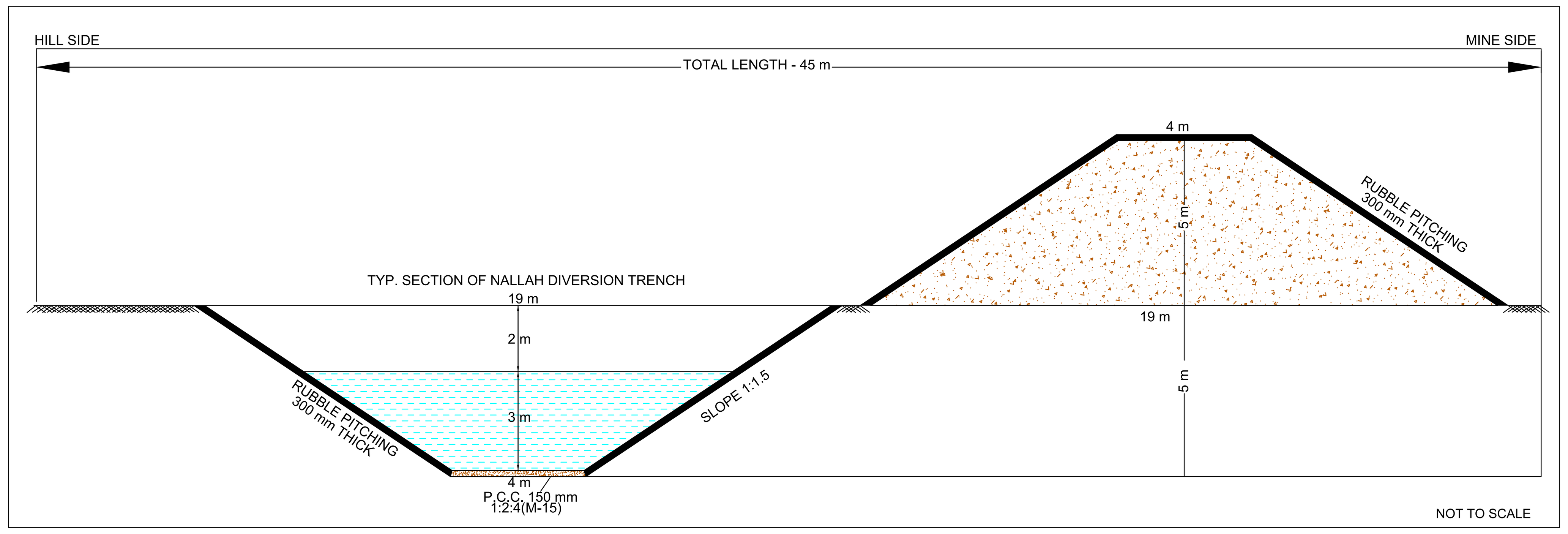
INDEX

Sr. No.	Details	Page No.
1	**MASTER PLAN OF NALA DIVERSION TRENCH**	1
2	**NALA DIVERSION TRENCH**	2
3	**100 M SECTION BOUNDARY**	3
4	**SECTION ABC**	4
5	**TYP.SECTION OF NALLAH DIVERSION TRENCH**	5
6	P-1	6
7	P-2	7
8	P-3	8
9	P-4	9
10	P-5	10
11	P-6	11
12	P-7	12
13	P-8	13
14	P-9	14
15	P-10	15
16	P-11	16
17	P-12	17
18	P-13	18
19	P-14	19
20	P-15	20
21	P-16	21
22	P-17	22
23	P-18	23
24	P-19	24
25	P-20	25
26	P-21	26
27	P-22	27
28	P-23	28
29	P-24	29
30	P-25	30
31	P-26	31
32	P-27	32

MASTER PLAN OF NALA DIVERSION TRENCH







Stratatech Mineral Resources Private Limited. (SMRPL)

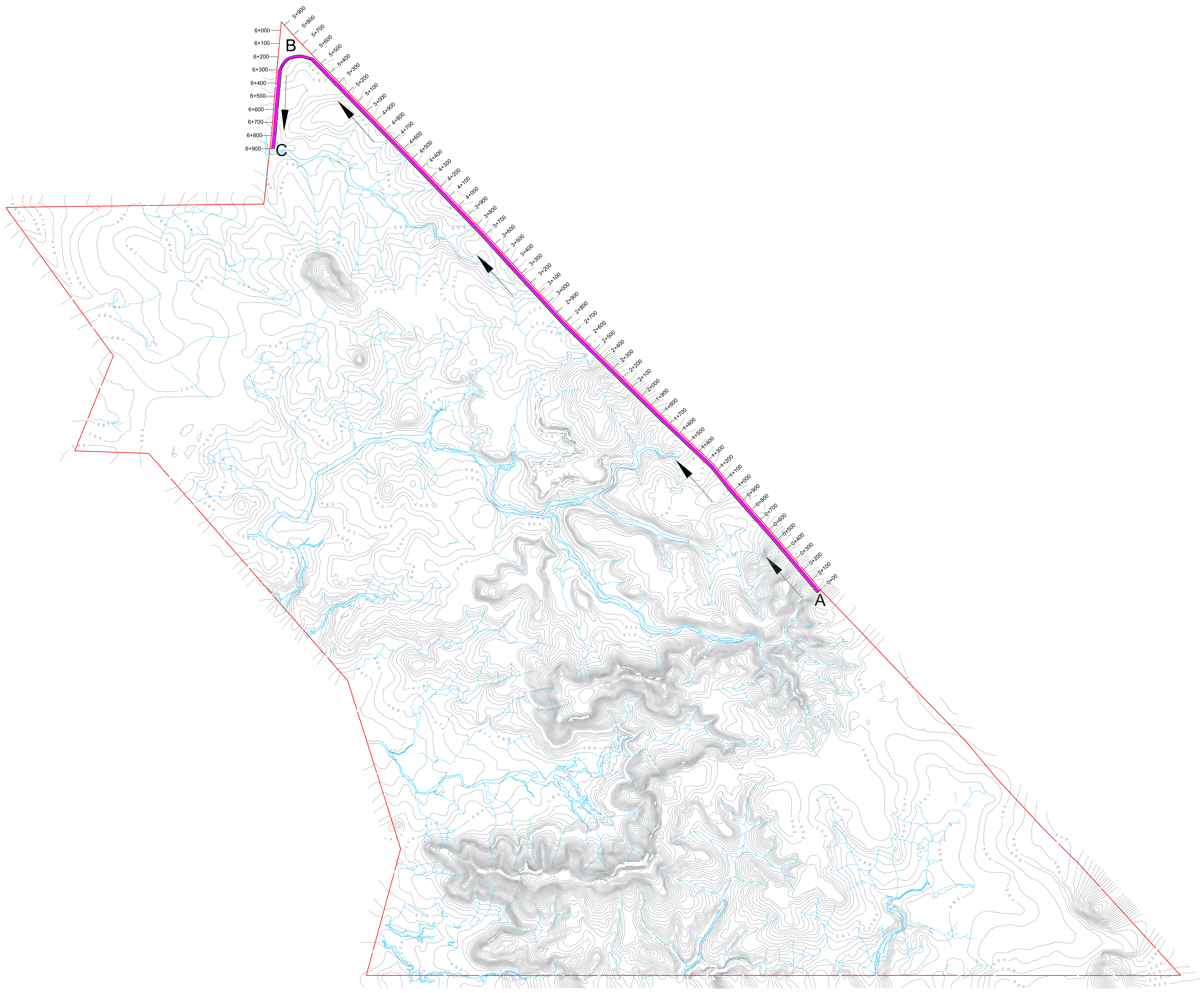
Mining Plan Including Mine closure Plan for

Dhirauli Coal Mine -6.50 MTPA (Opencast-5 MTPA & Underground-1.5 MTPA)

Scale 1:10000

SRUSHTI SEVA PRIVATE LIMITED

Bilvadal" 8 Janta Layout, Deendayal Nagar,
Nagpur (Maharashtra) - 440022
Landline : 0712 2971968
Email: srspl15@gmail.com , srushtisewa@yahoo.com


A
B
C
0+00
0+100
0+200
0+300
0+400
0+500
0+600
0+700
0+800
0+900
1+000
1+100
1+200
1+300
1+400
1+500
1+600
1+700
1+800
1+900
2+000
2+100
2+200
2+300
2+400
2+500
2+600
2+700
2+800
2+900
3+000
3+100
3+200
3+300
3+400
3+500
3+600
3+700
3+800
3+900
4+000
4+100
4+200
4+300
4+400
4+500
4+600
4+700
4+800
4+900
5+000
5+100
5+200
5+300
5+400
5+500
5+600
5+700
5+800
5+900
6+000
6+100
6+200
6+300
6+400
6+500
6+600
6+700
6+800
6+900

Stratatech Mineral Resources Private Limited. (SMRPL)

Mining Plan Including Mine closure Plan for

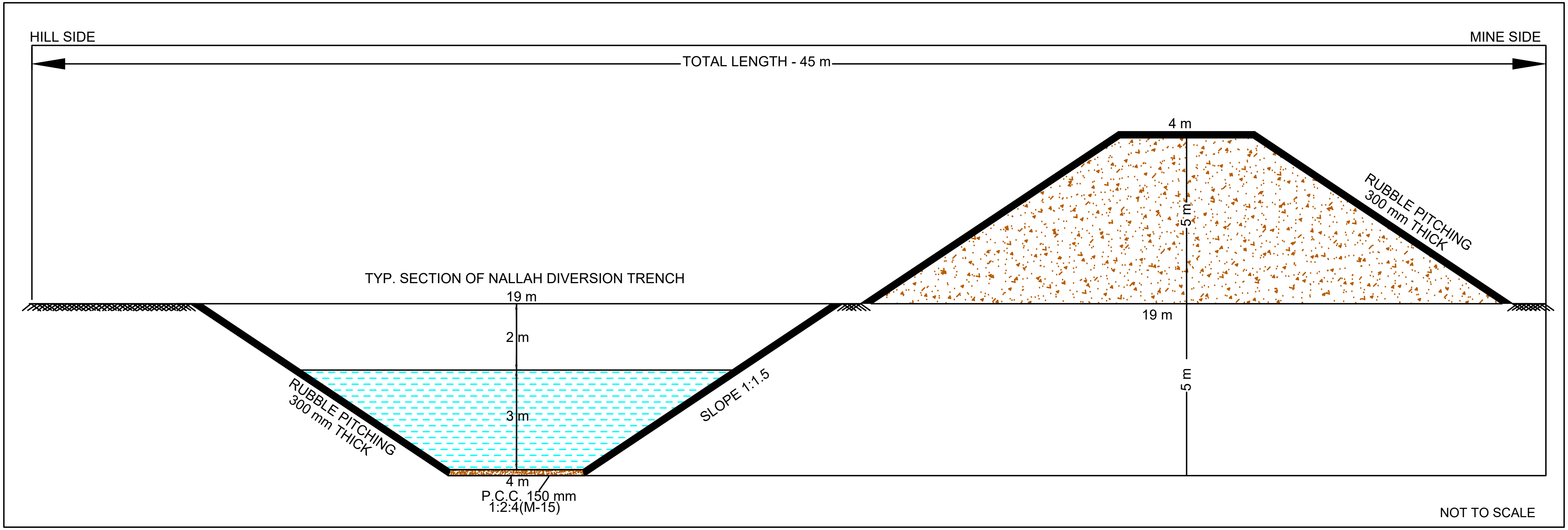
Dhirauli Coal Mine -6.50 MTPA (Opencast-5 MTPA & Underground-1.5 MTPA)

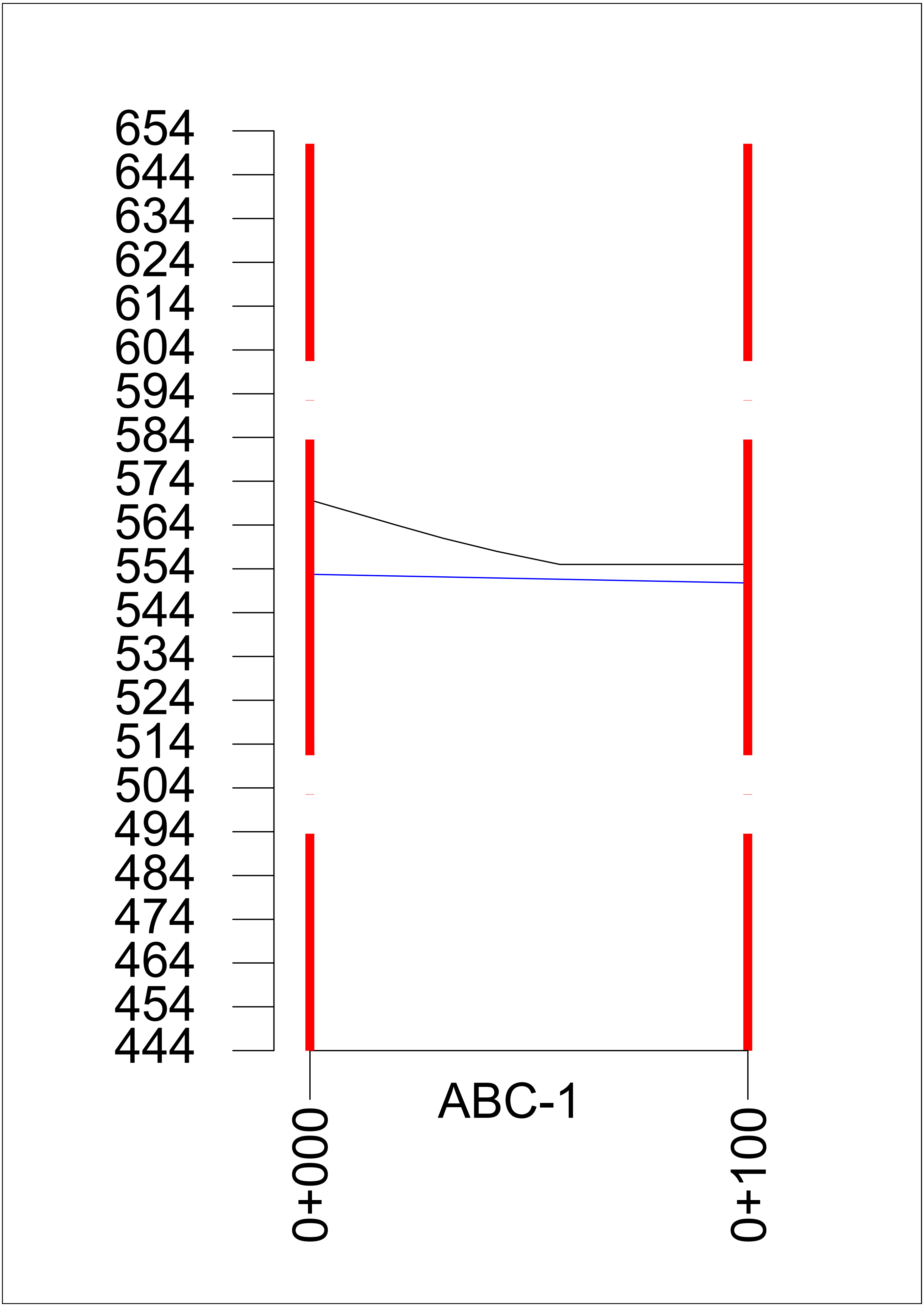
Scale 1:10000

SRUSHTI SEVA PRIVATE LIMITED

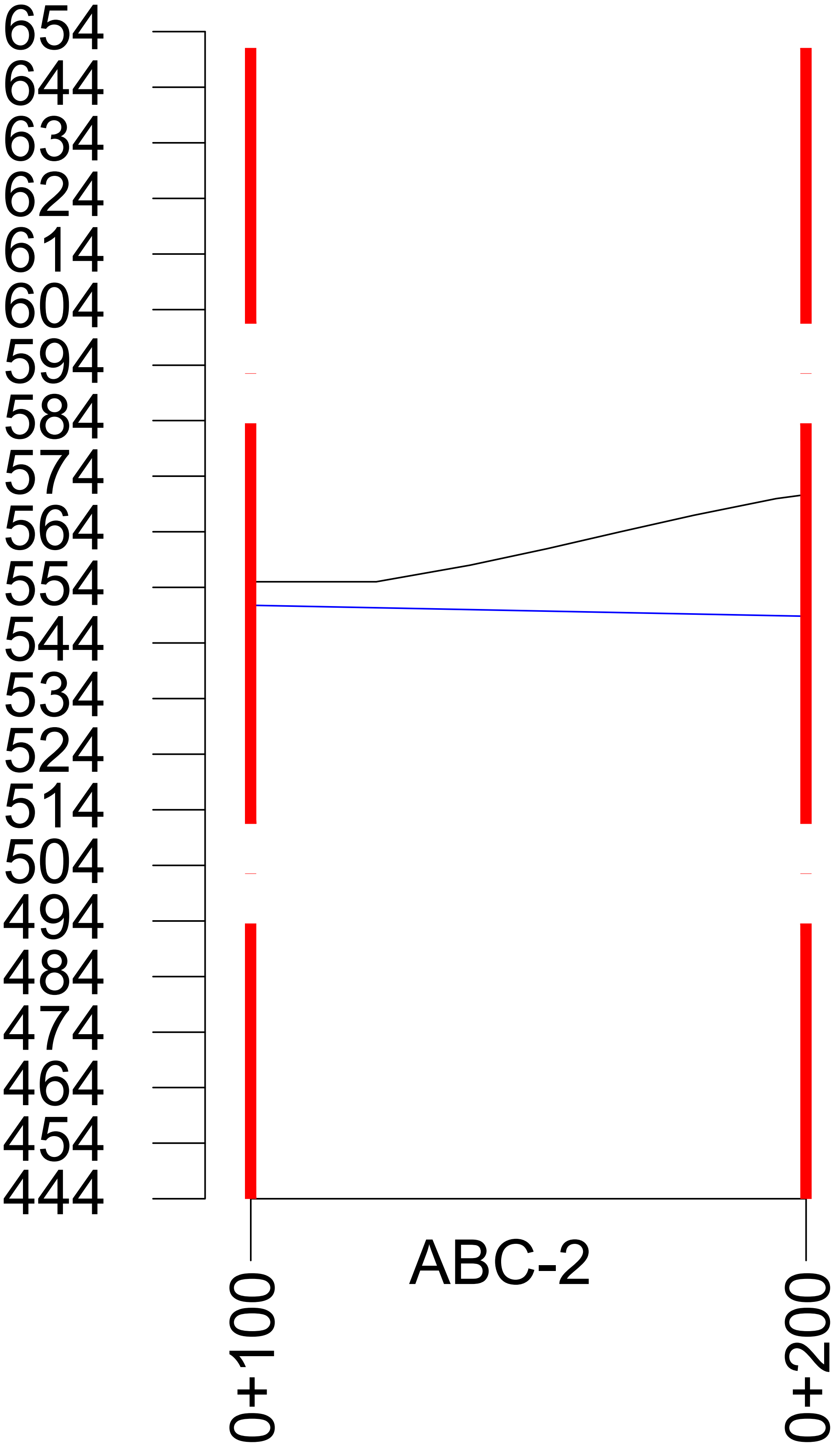
Bilvadal" 8 Janta Layout, Deendayal Nagar,
Nagpur (Maharashtra) - 440022
Landline : 0712 2971968
Email: srspl15@gmail.com , srushtisewa@yahoo.com


VERTICAL SCALE 1:10
HORIZONTAL SCALE 1:10000
RL- 555m
START POINT
RL- 489m
TURNING POINT
RL- 484m
END POINT
A
B
C
SECTION A - B - C

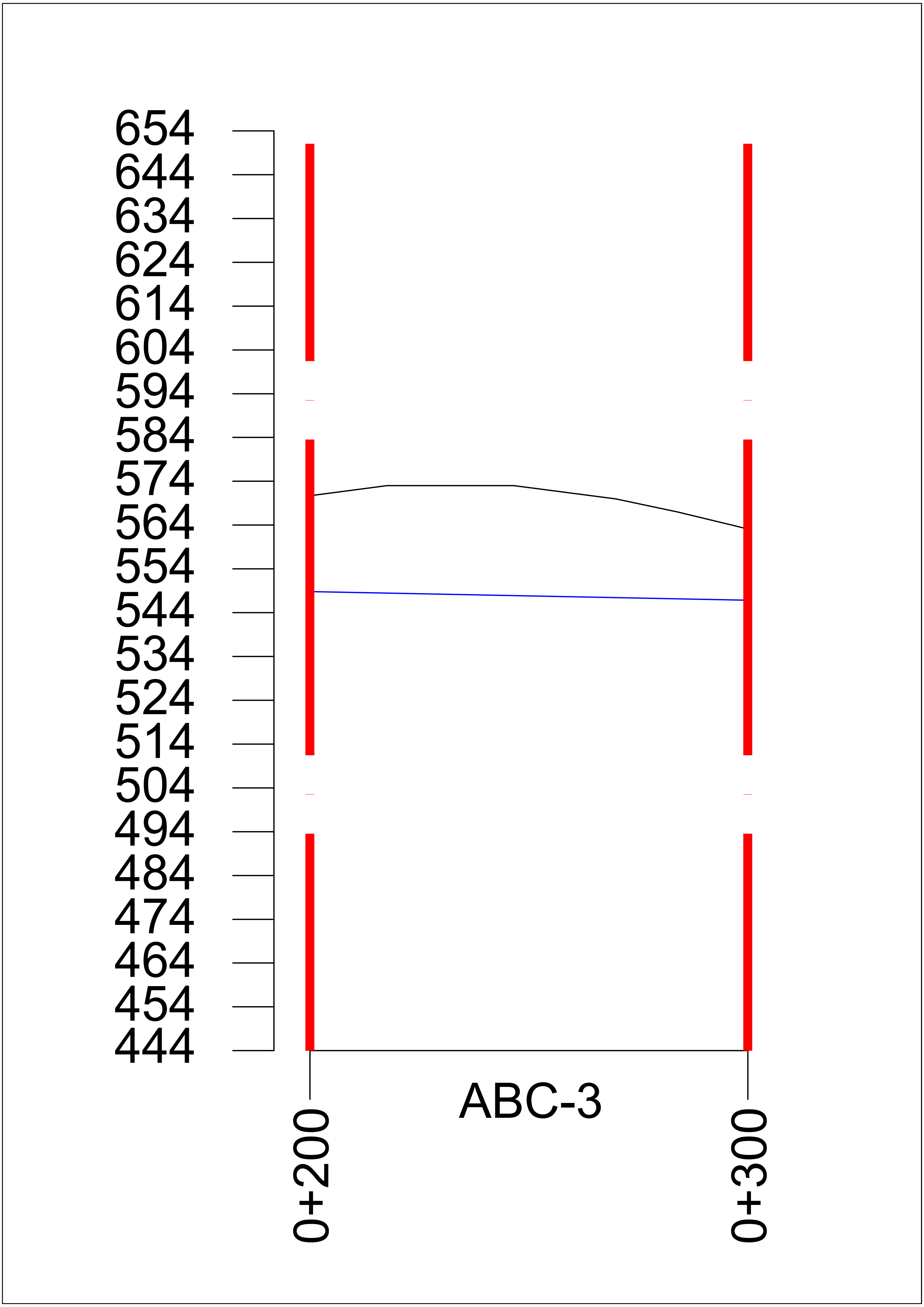

HILL SIDE
MINE SIDE
TOTAL LENGTH - 45 m
4 m
RUBBLE PITCHING
300 mm THICK
5 m
TYP. SECTION OF NALLAH DIVERSION TRENCH
19 m
2 m
19 m
RUBBLE PITCHING
300 mm THICK
3 m
SLOPE 1:1.5
5 m
4 m
P.C.C. 150 mm
1:2:4(M-15)
NOT TO SCALE

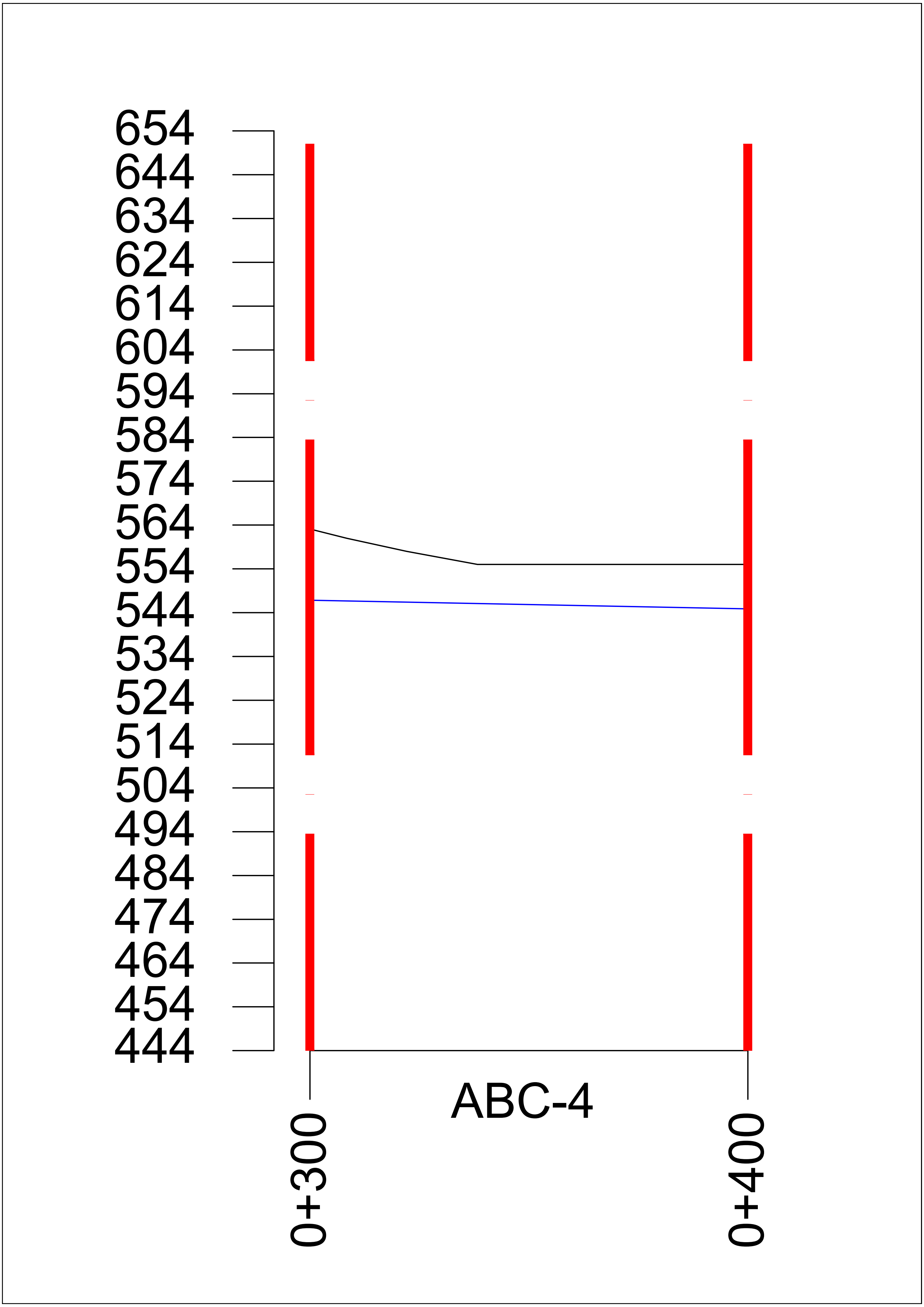


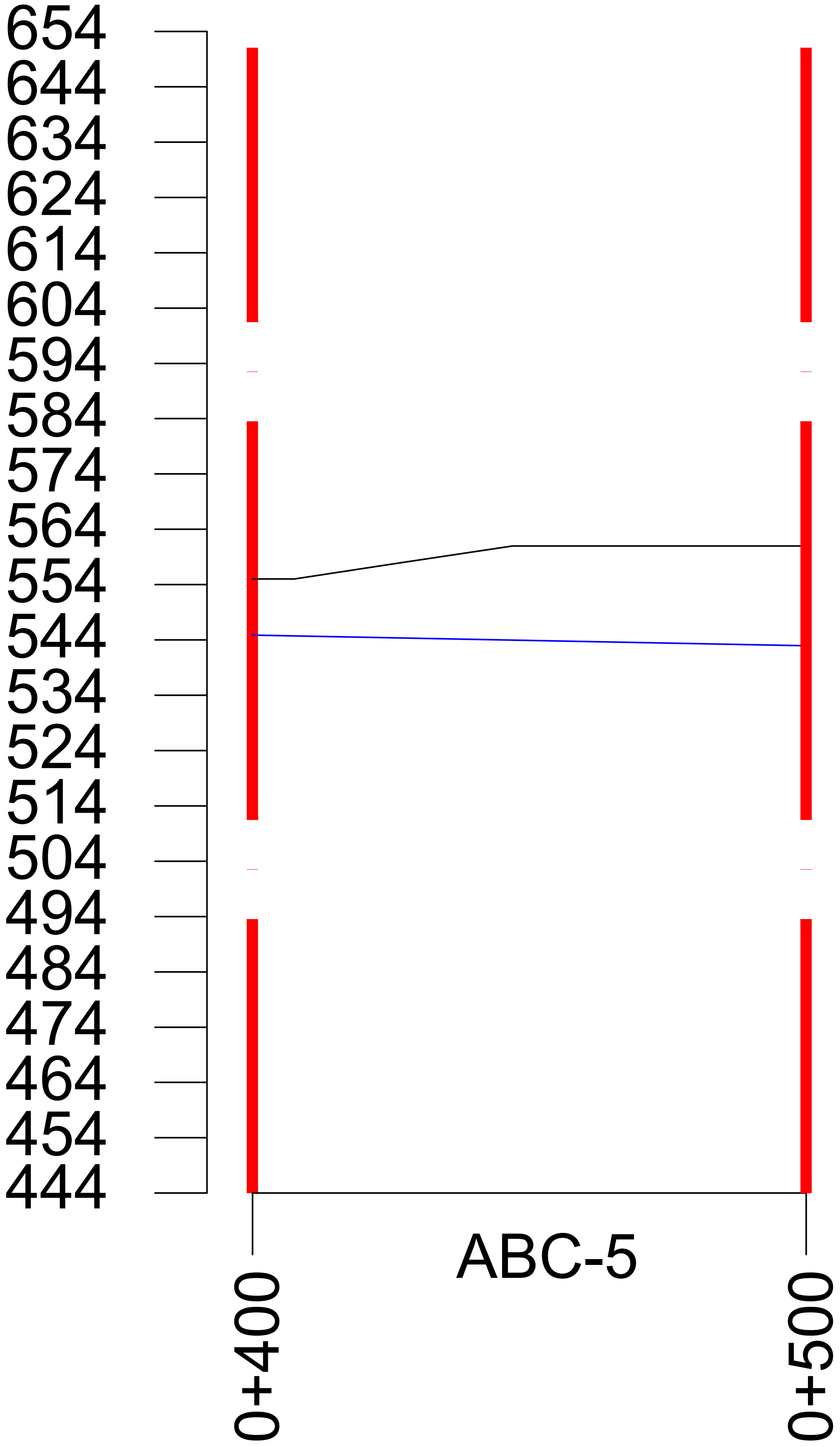
654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-1
0+000
0+100

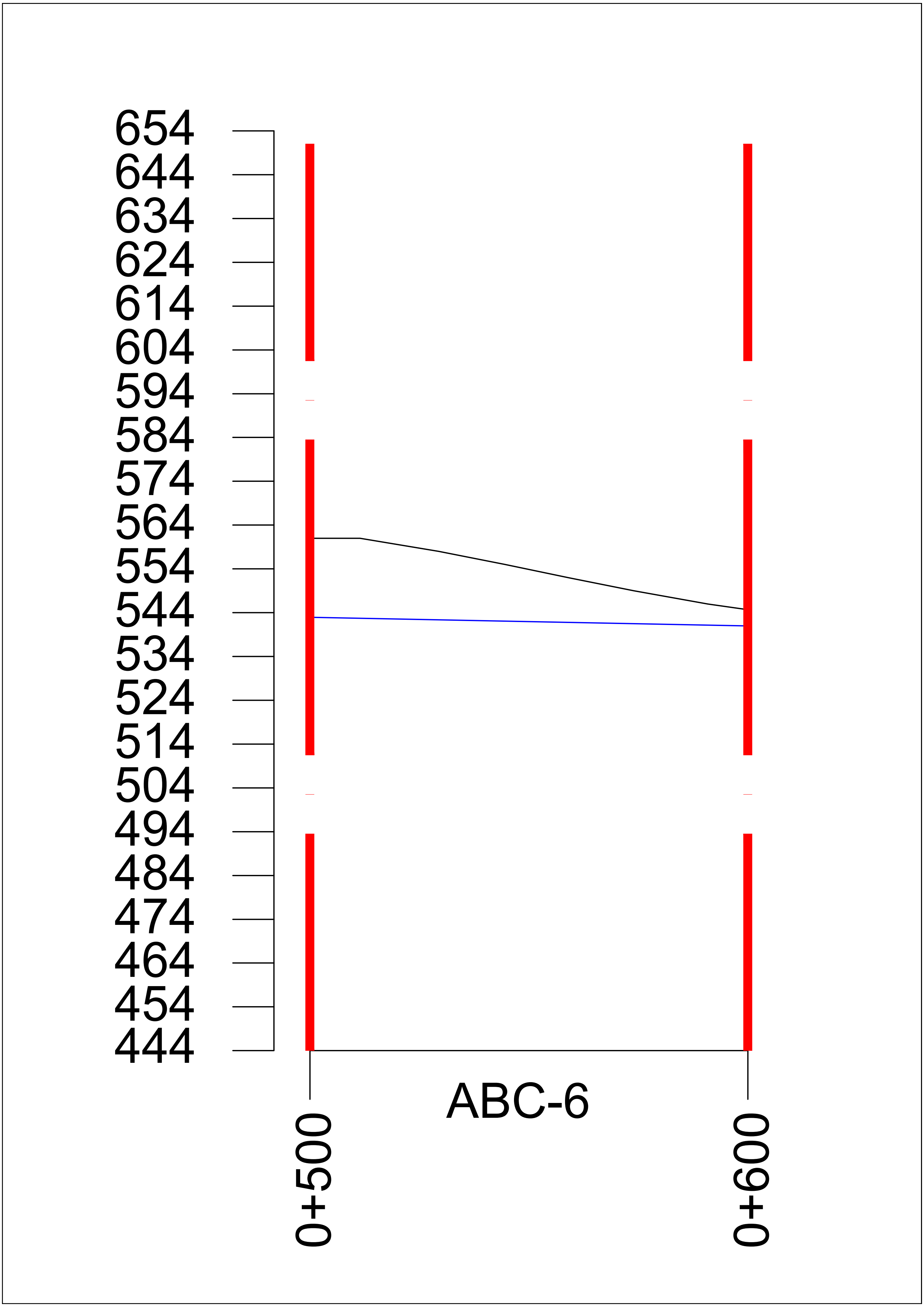


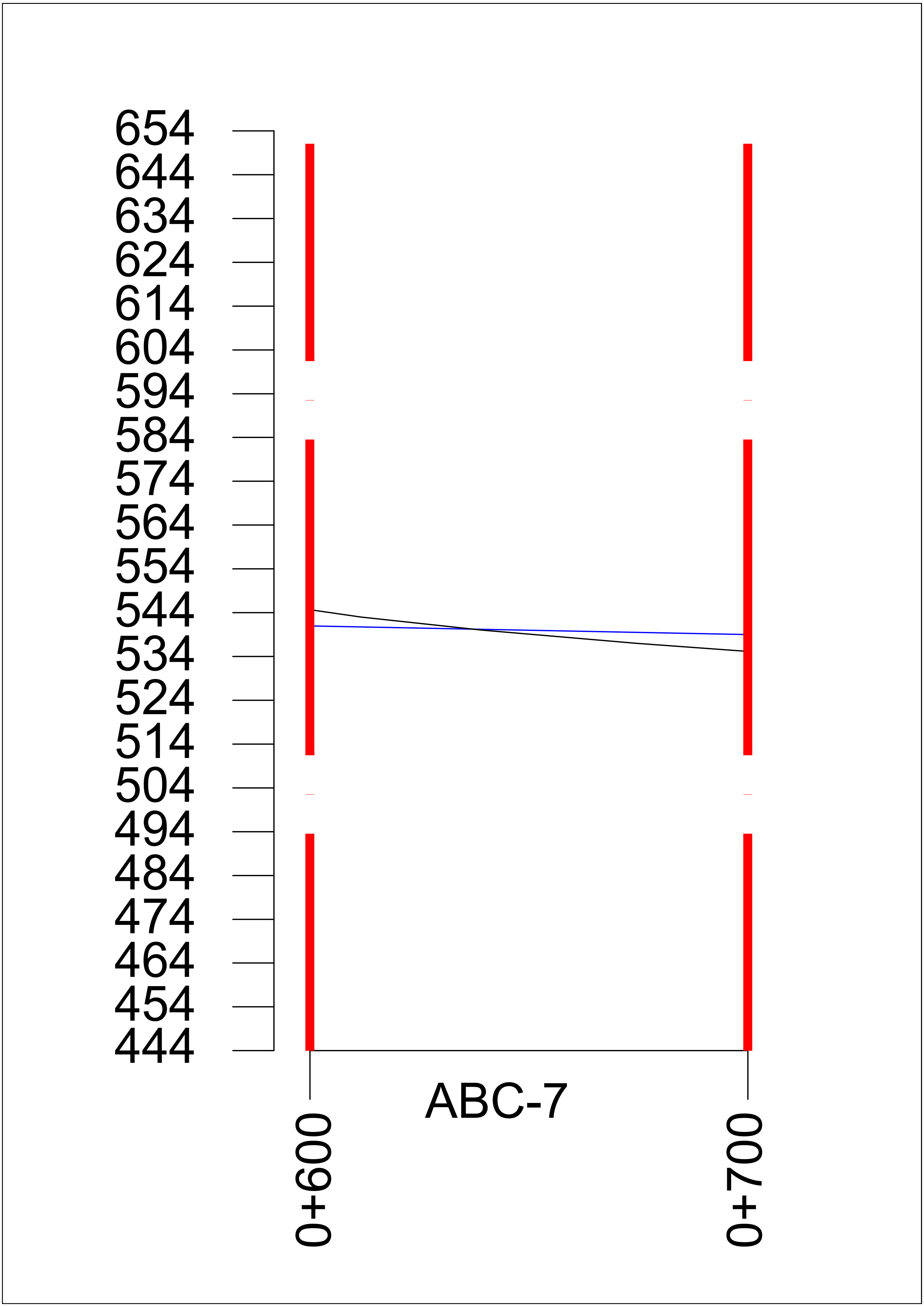
654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-2
0+100
0+200

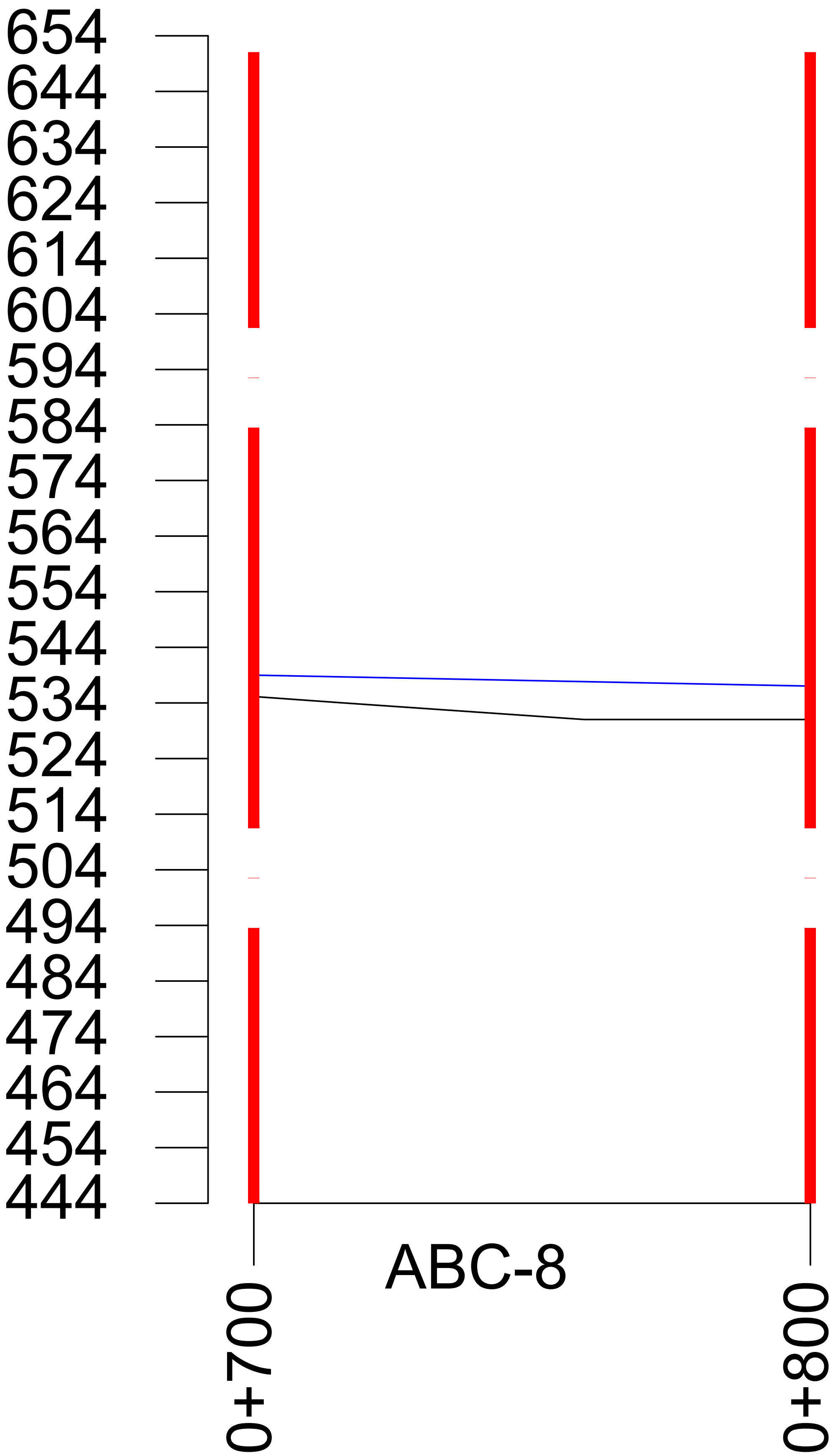

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-3
0+200
0+300

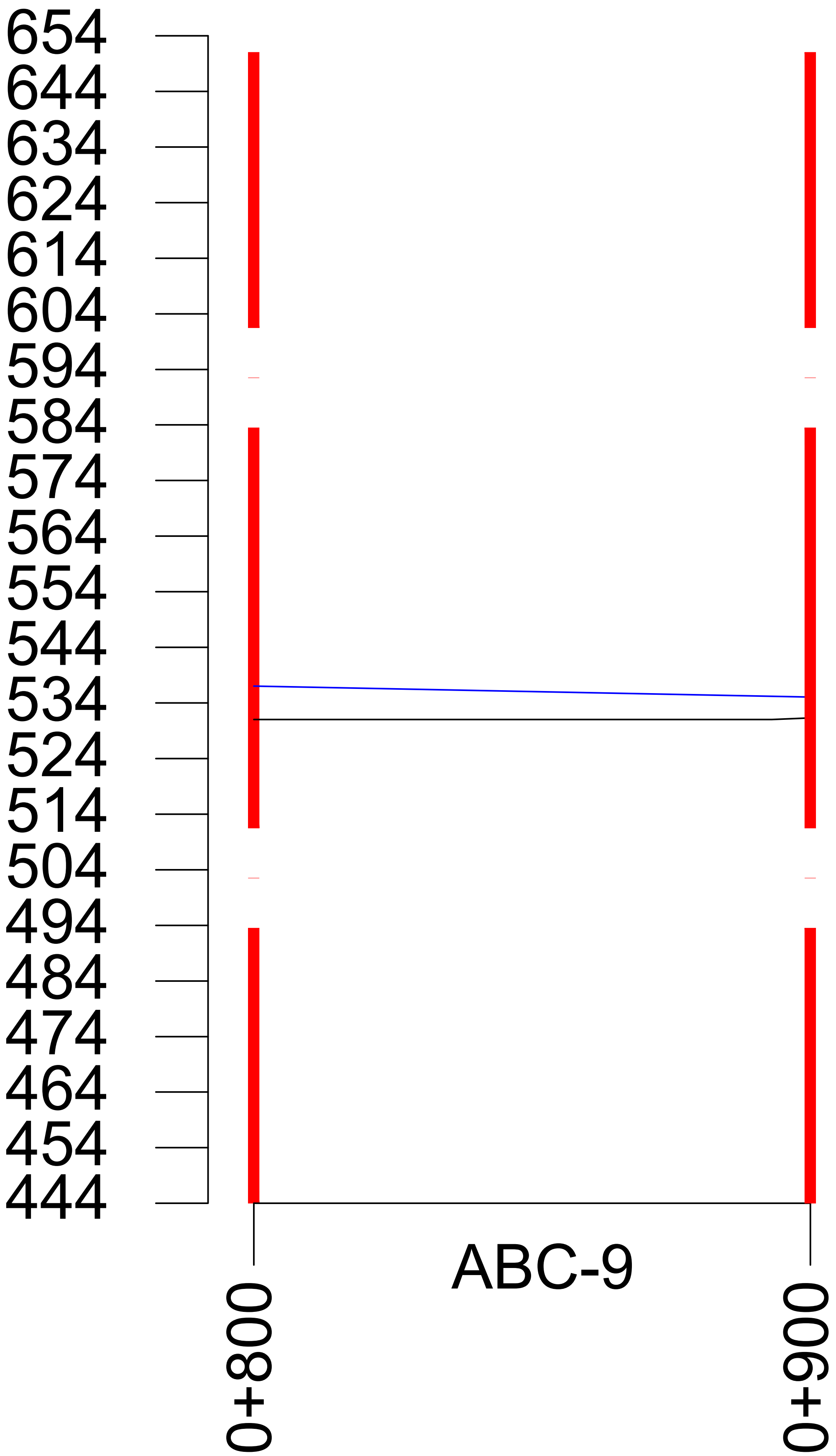

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-4
0+300
0+400

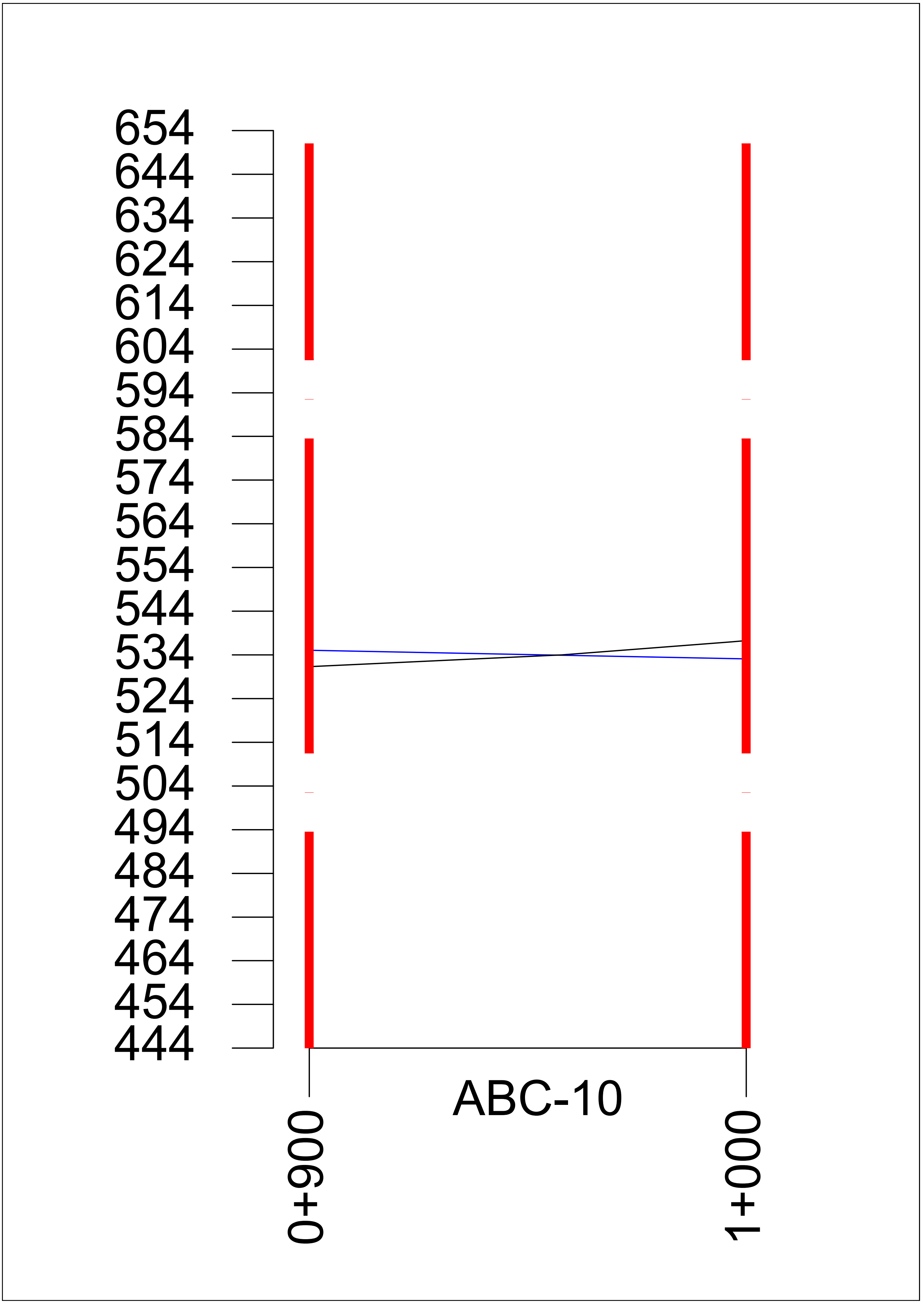

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-5
0+400
0+500

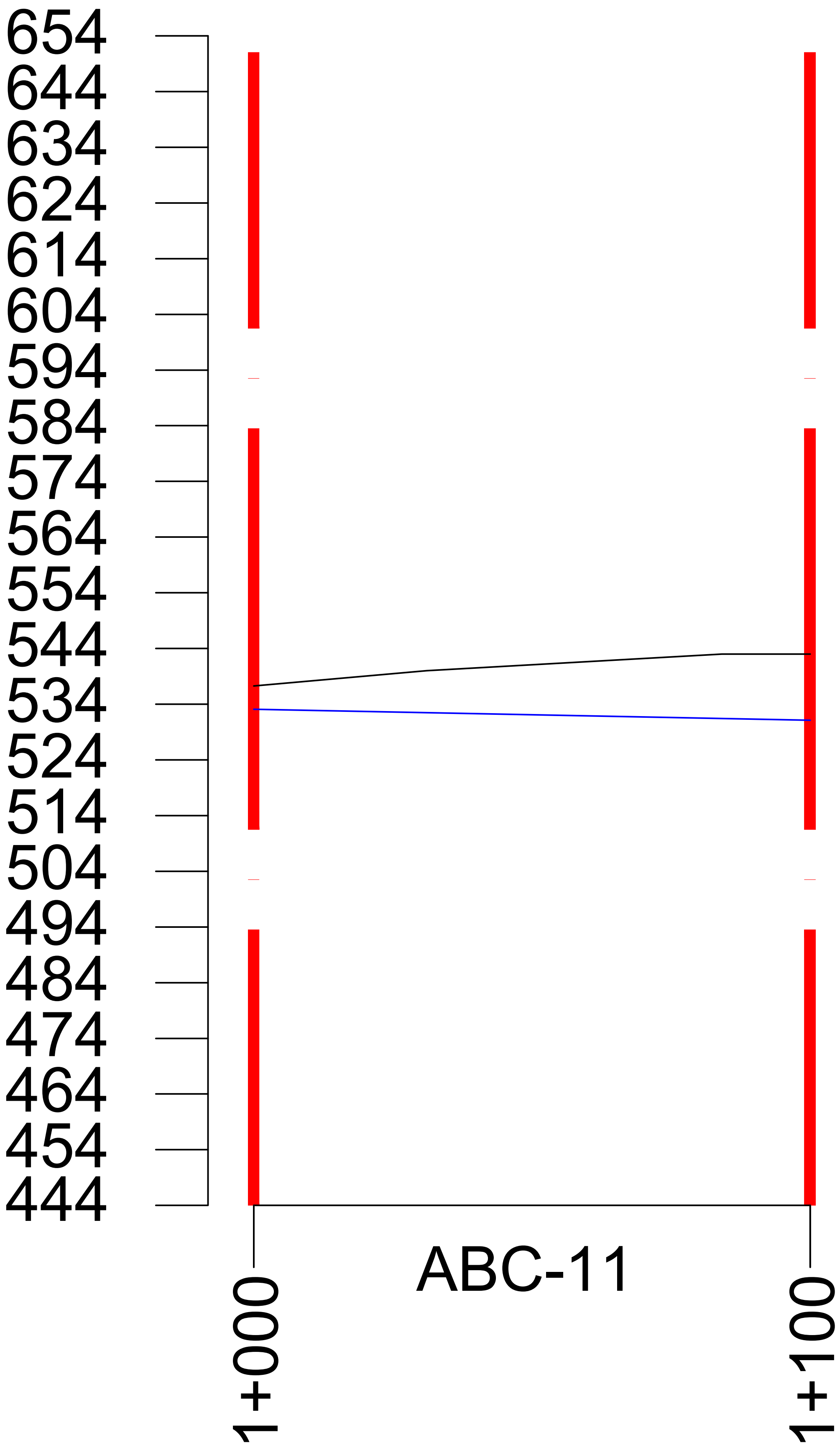

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-6
0+500
0+600

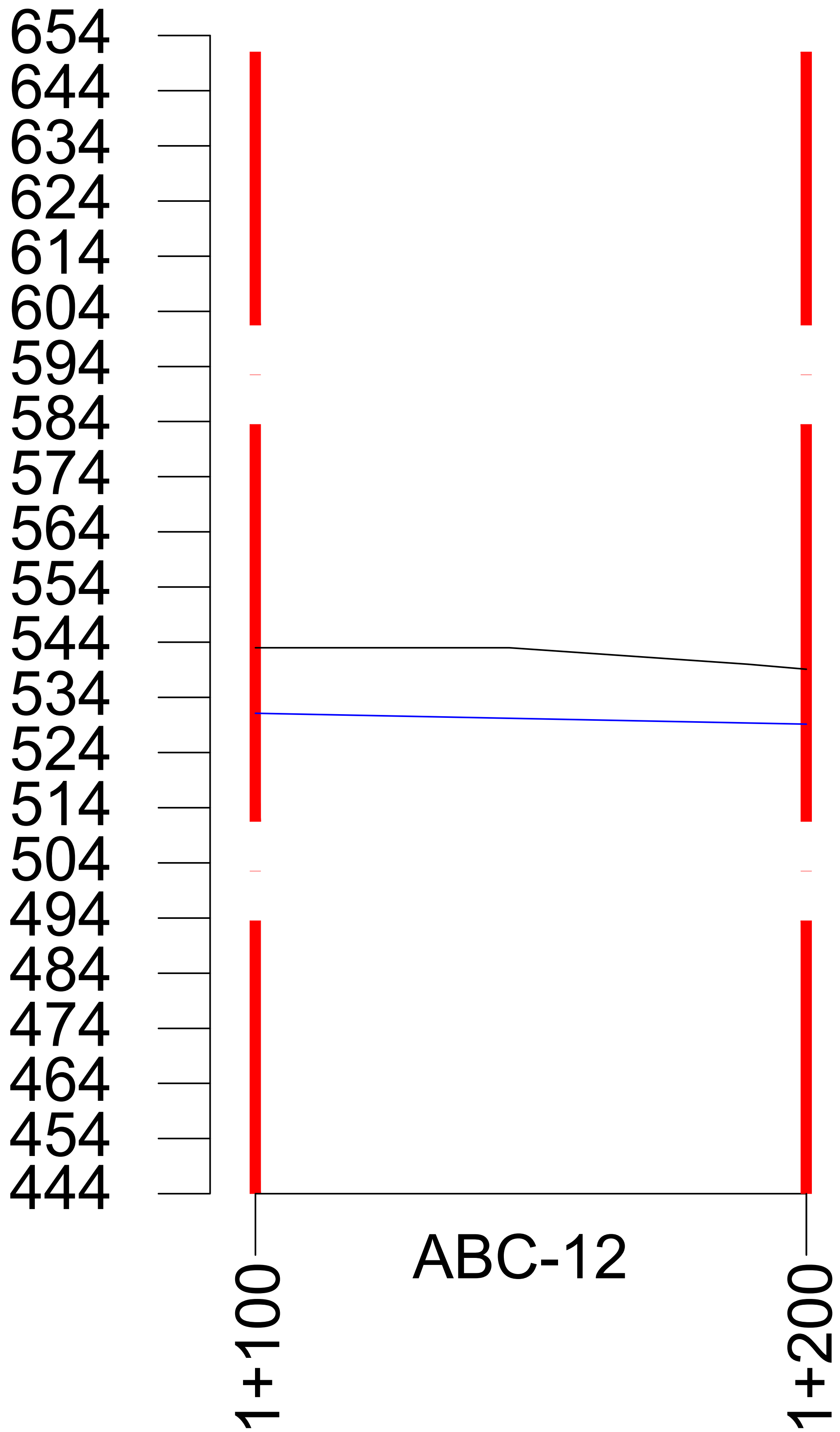

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-7
0+600
0+700

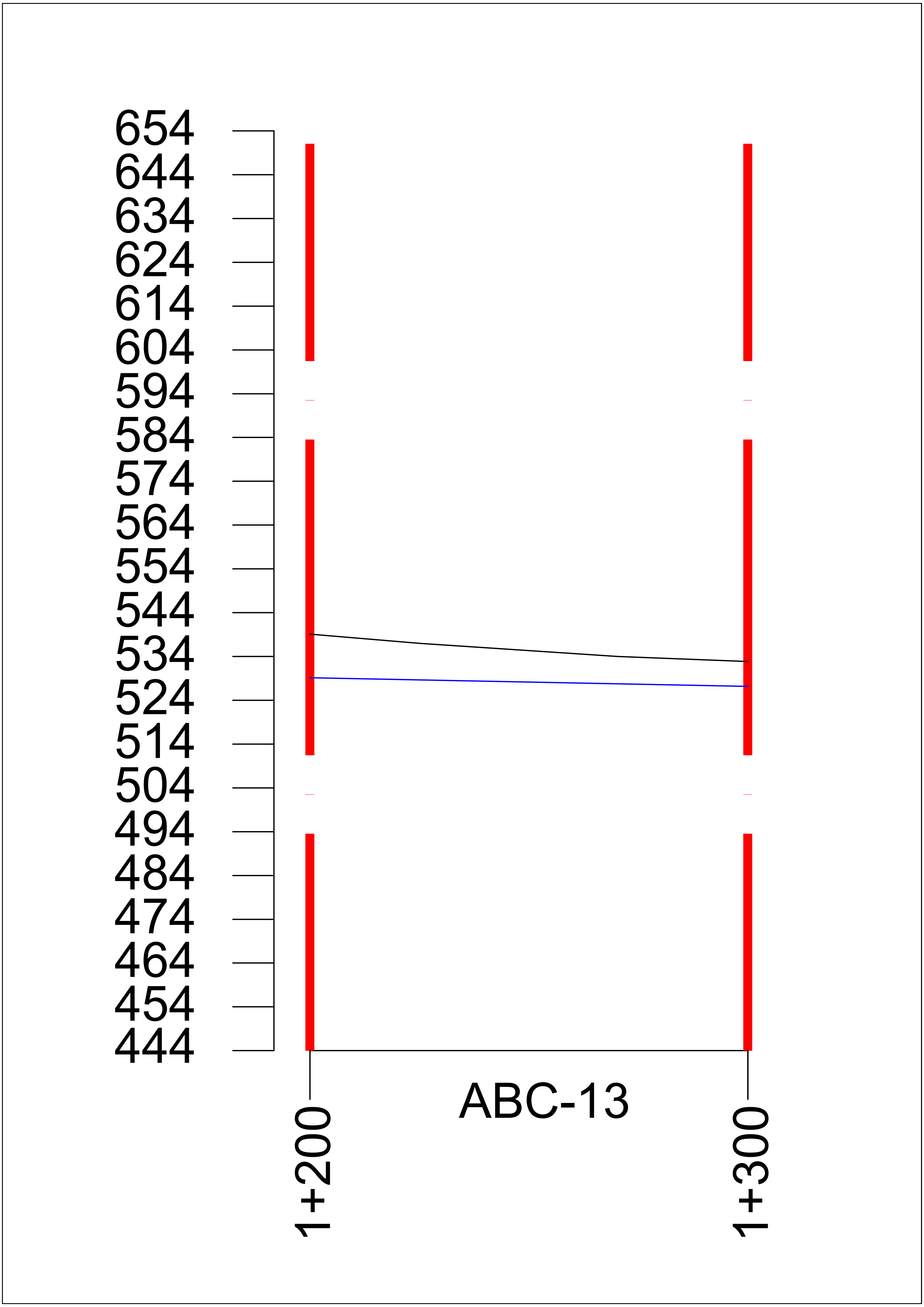

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-8
0+700
0+800

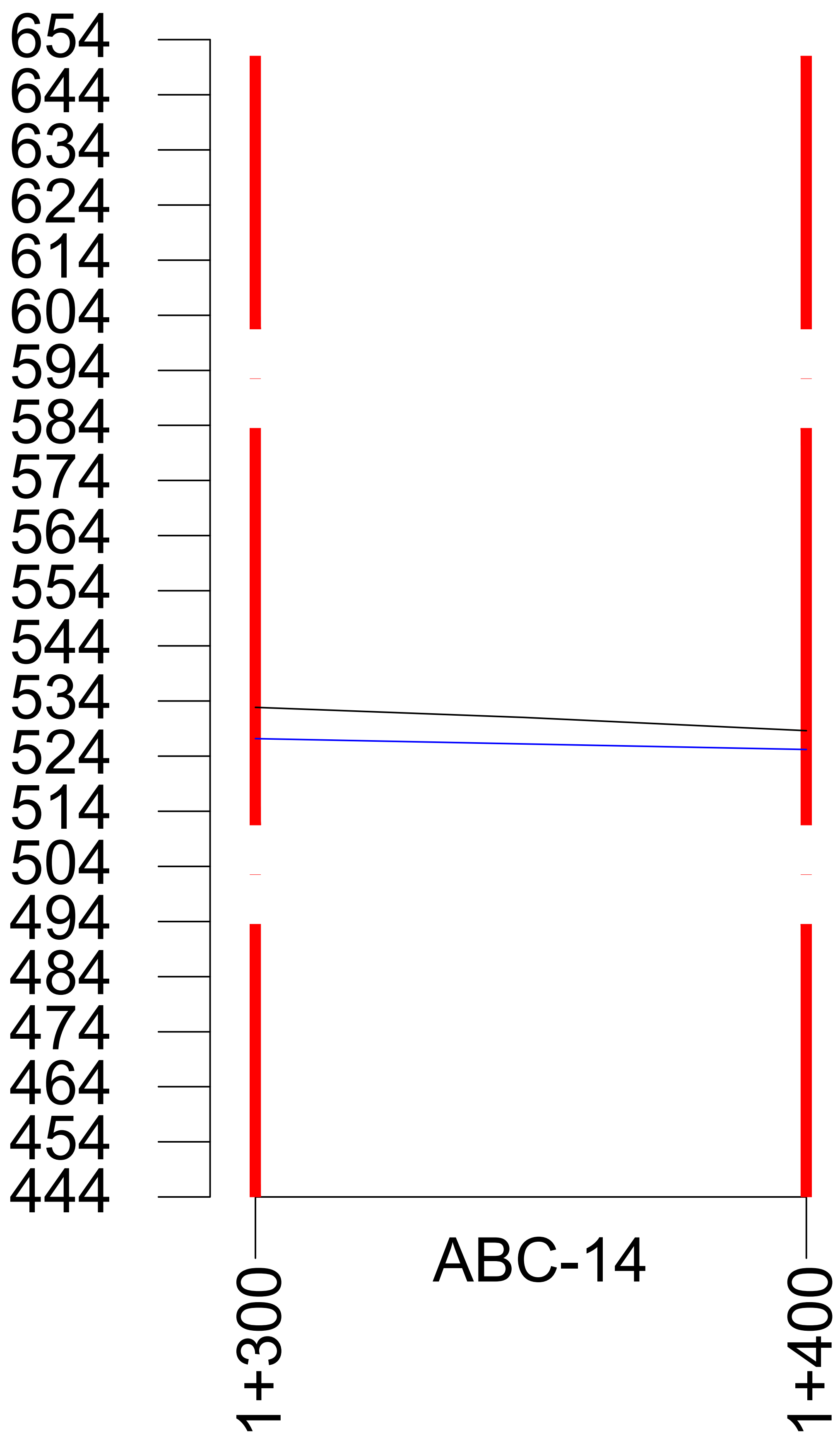

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-9
0+800
0+900

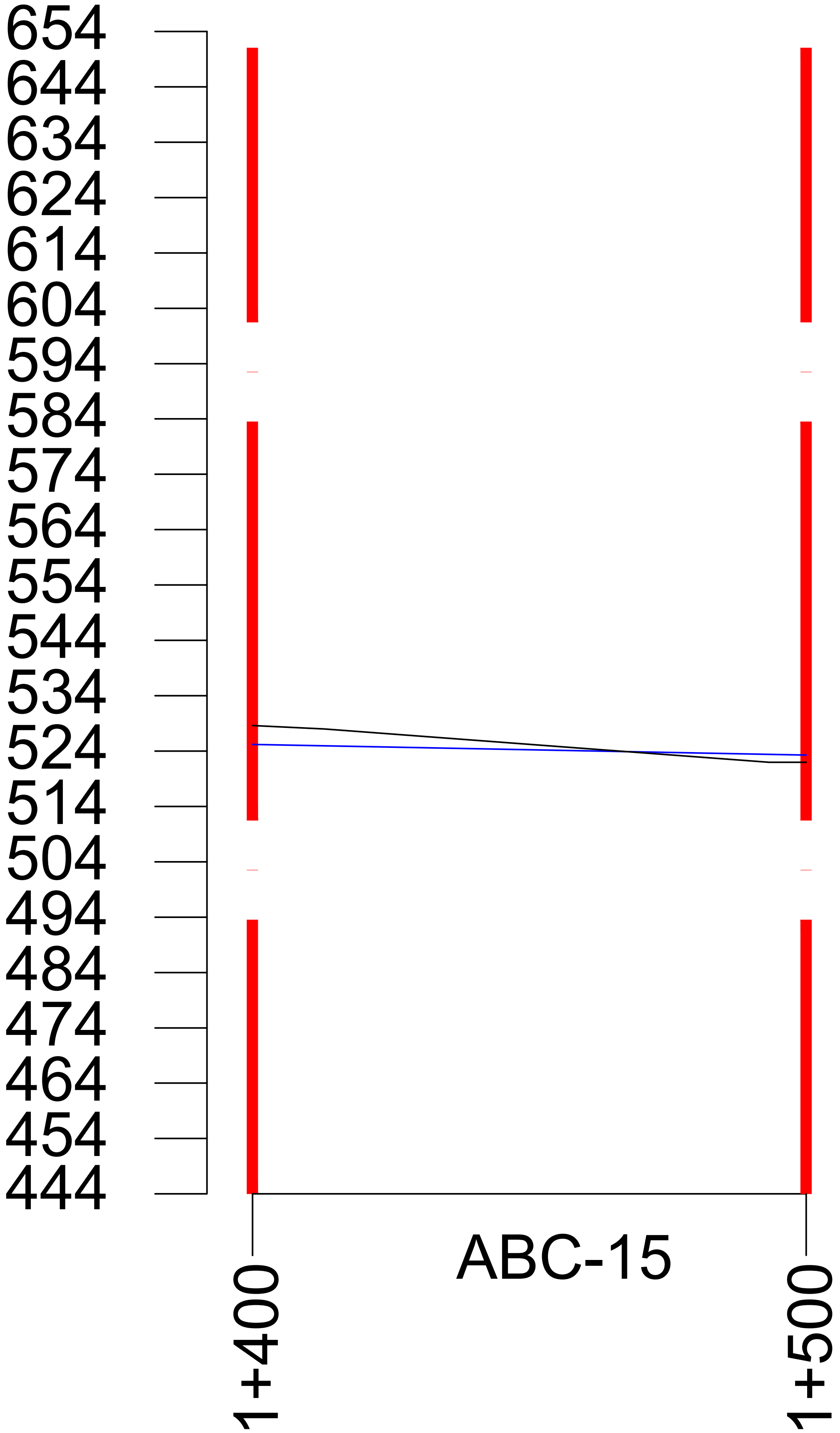

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-10
0+900
1+000

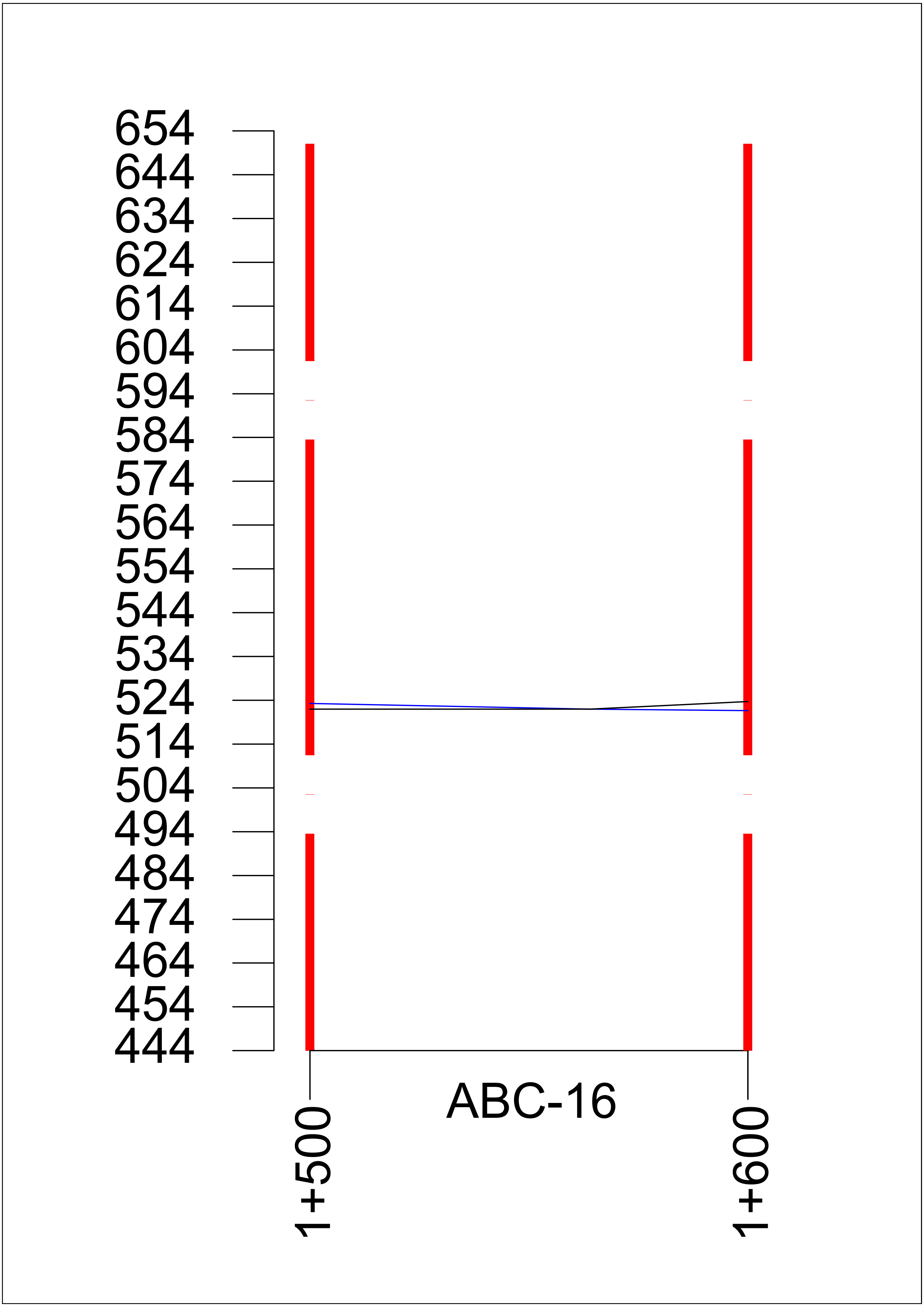

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-11
1+000
1+100

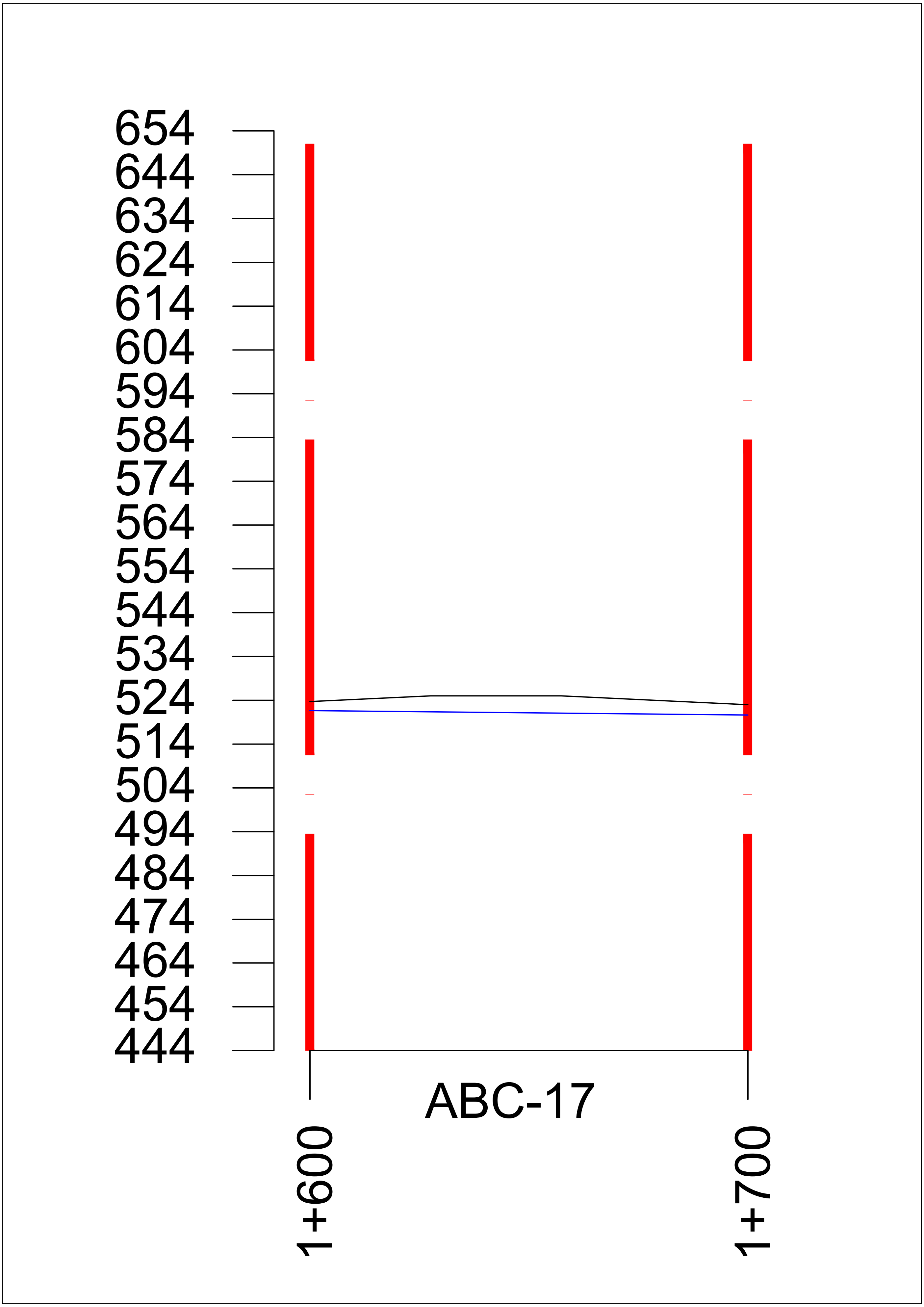

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-12
1+100
1+200

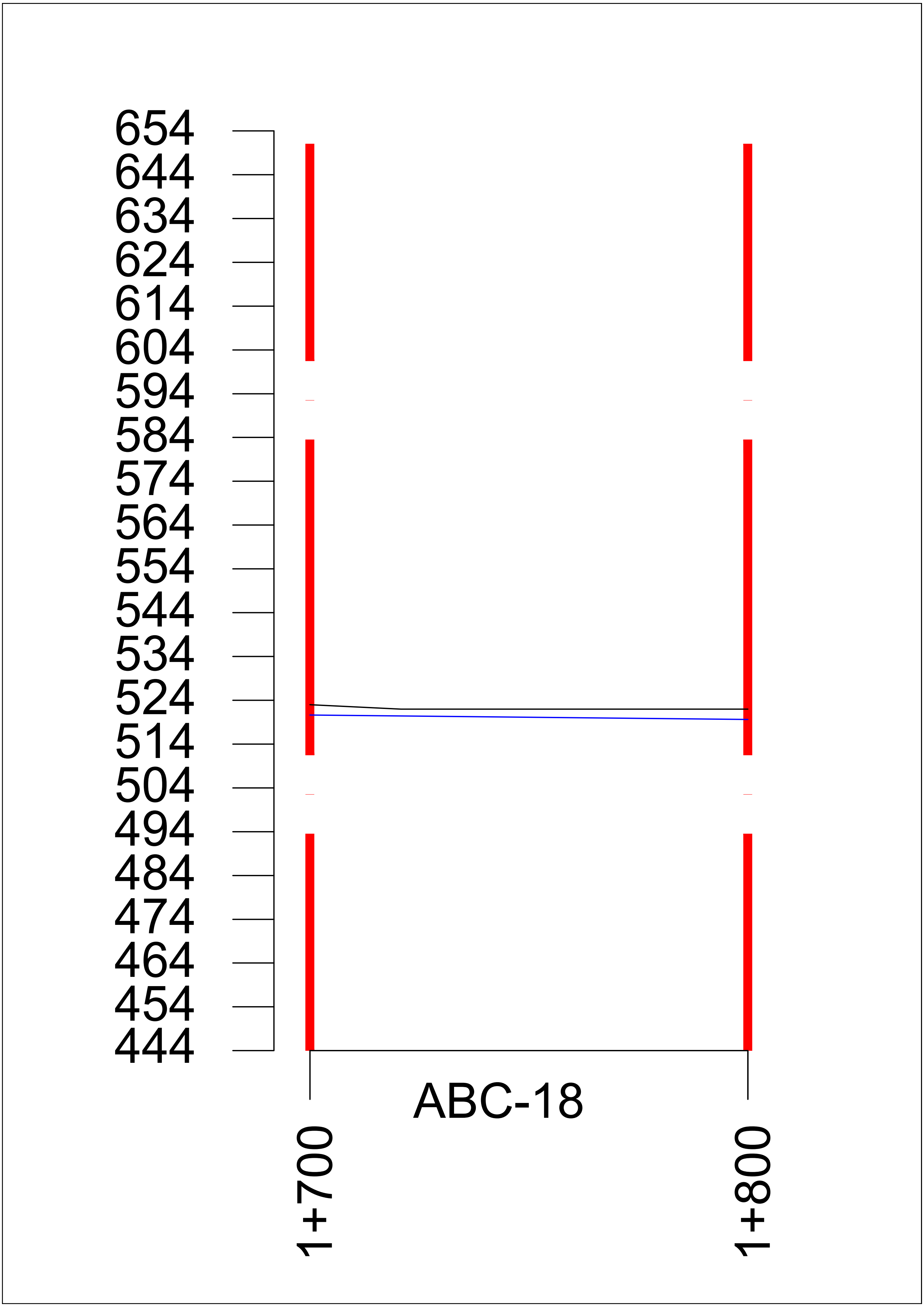

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-13
1+200
1+300


654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-14
1+300
1+400

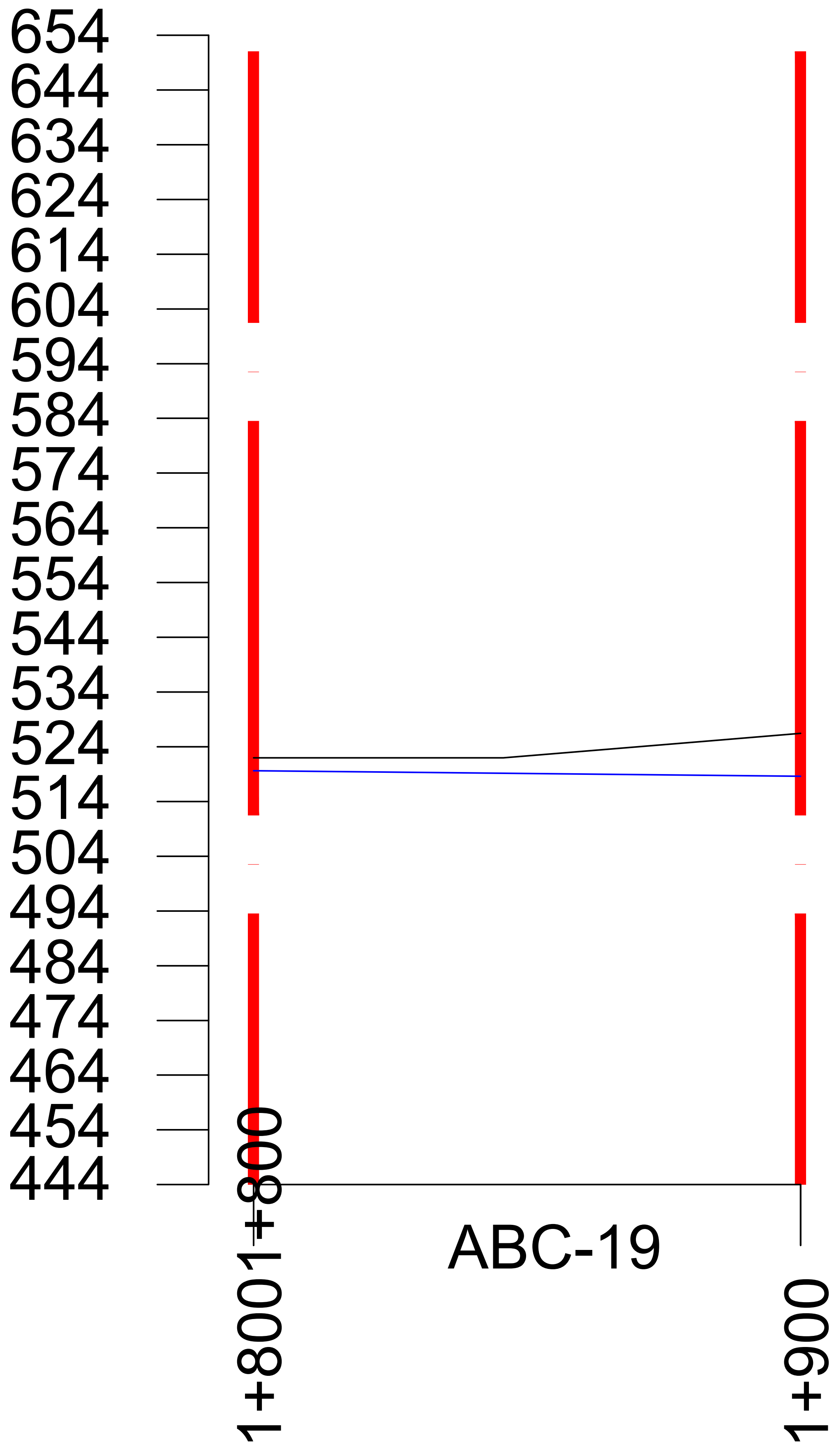

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-15
1+400
1+500

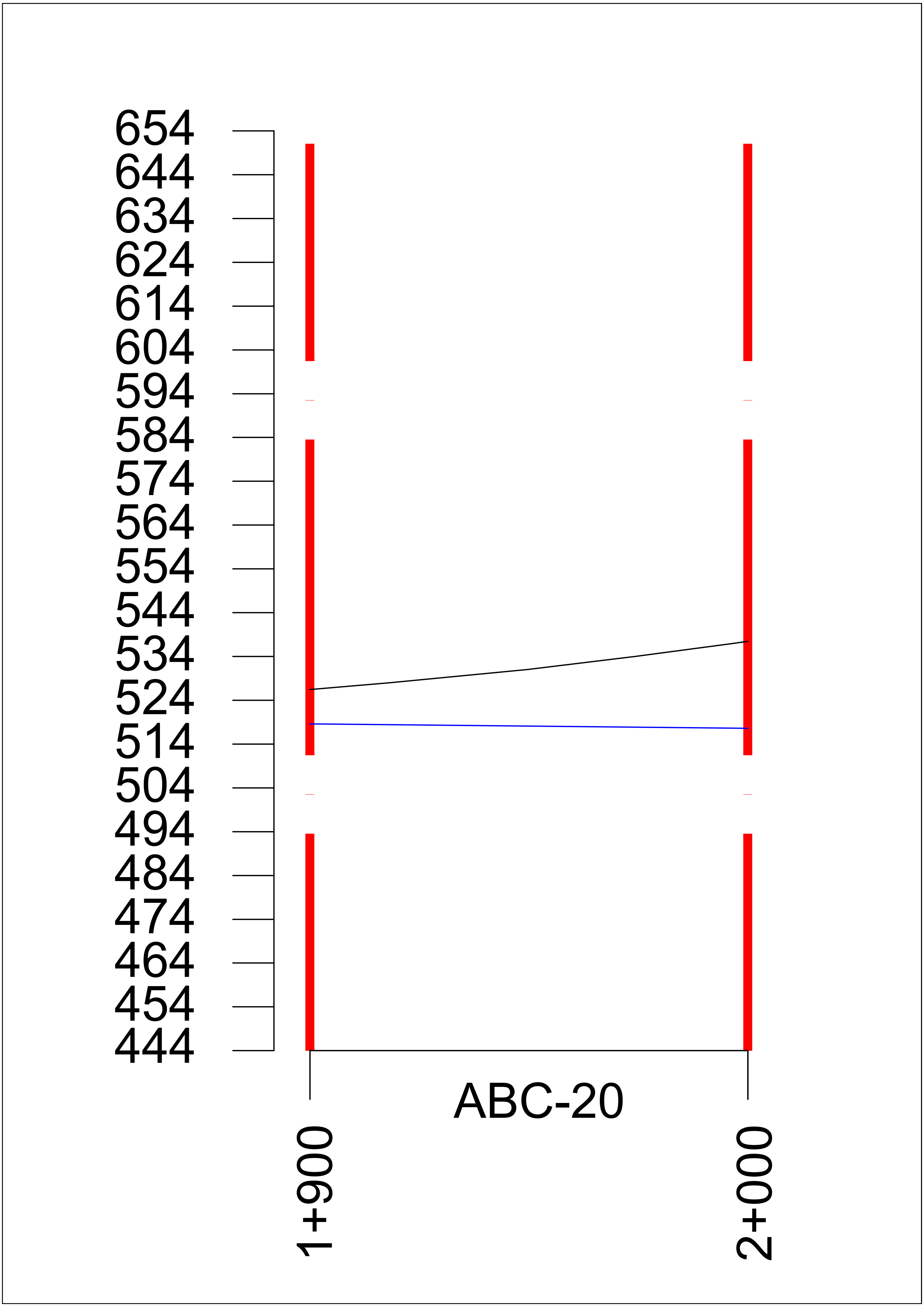

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-16
1+500
1+600

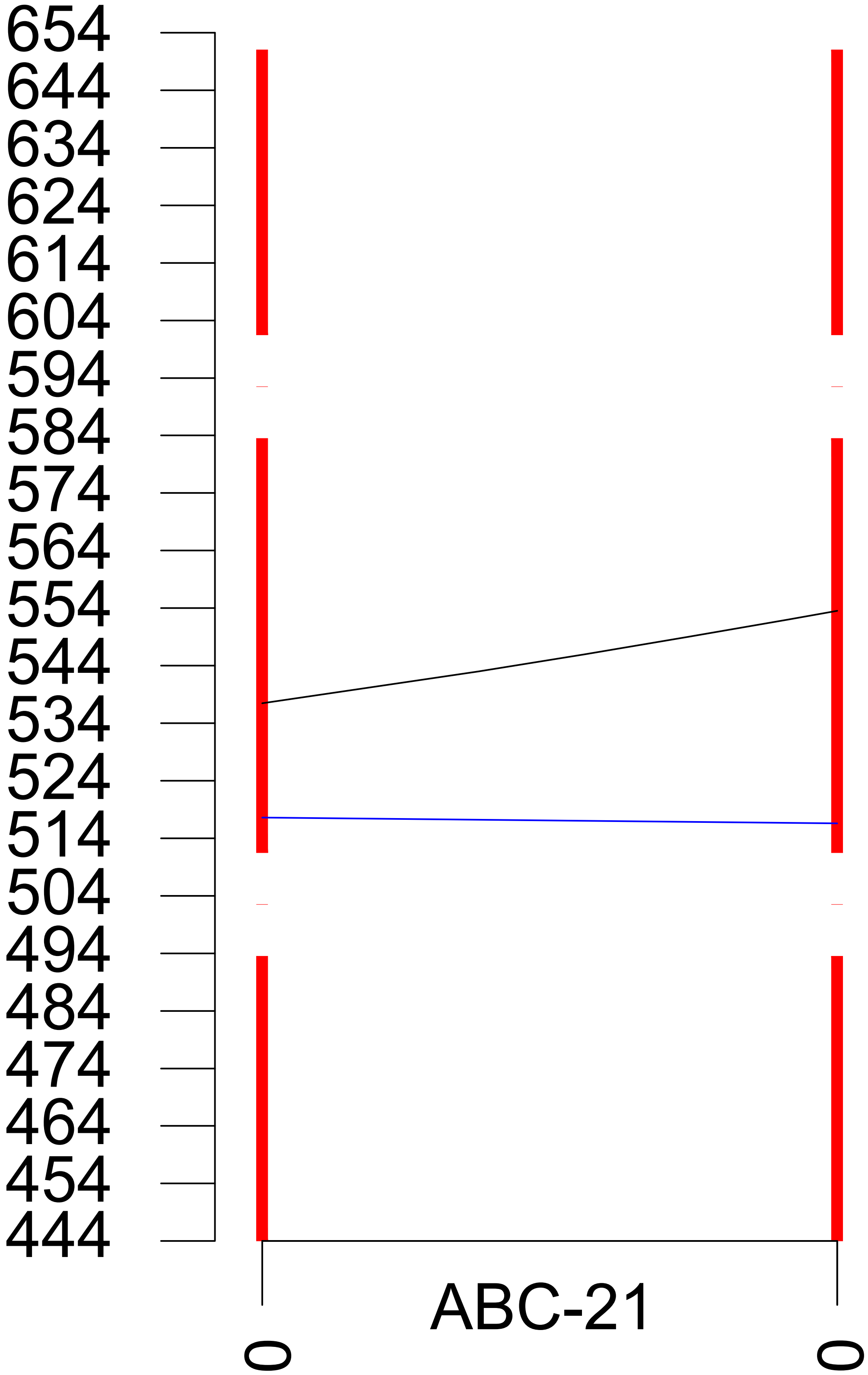

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-17
1+600
1+700



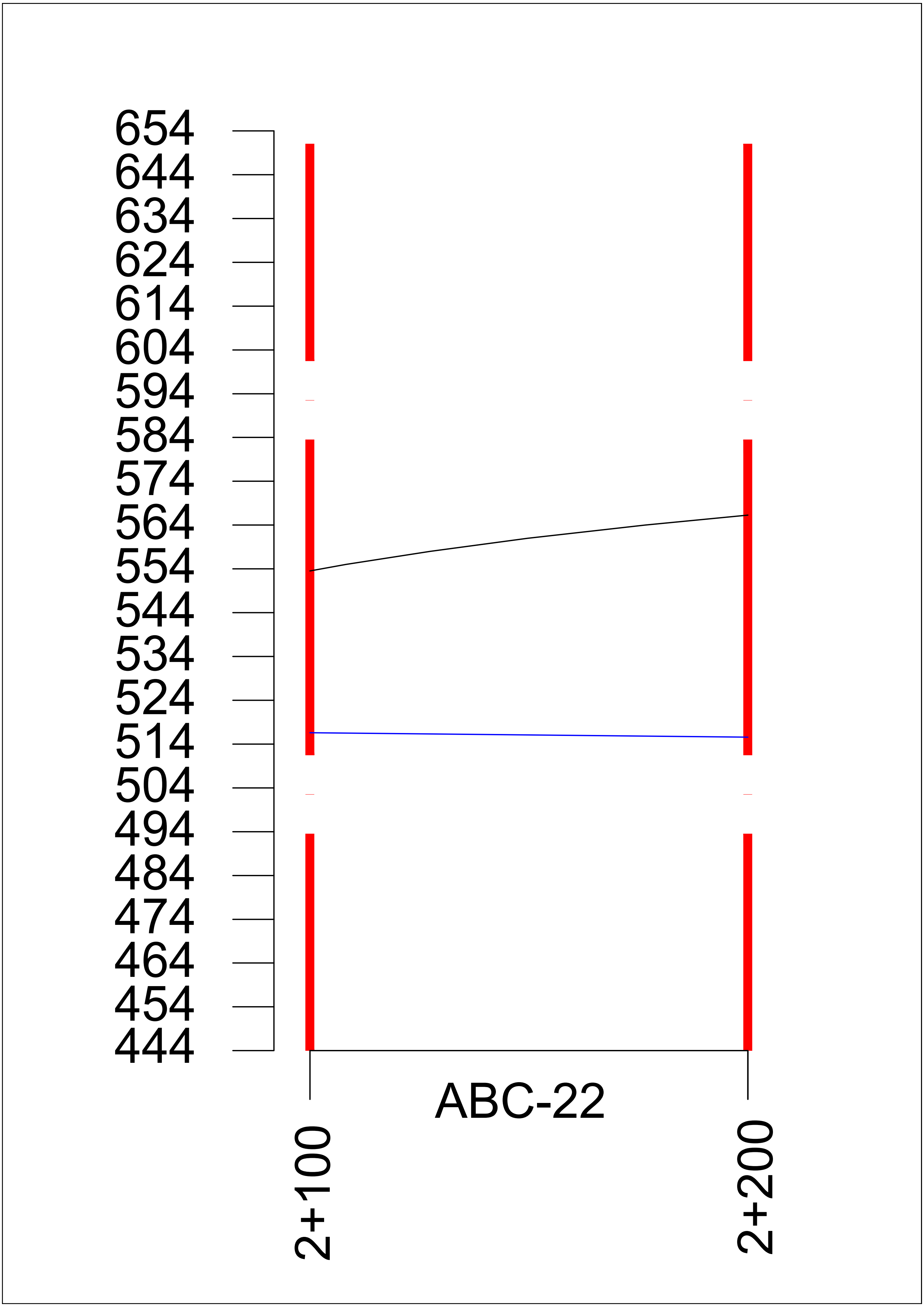
654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-18
1+700
1+800

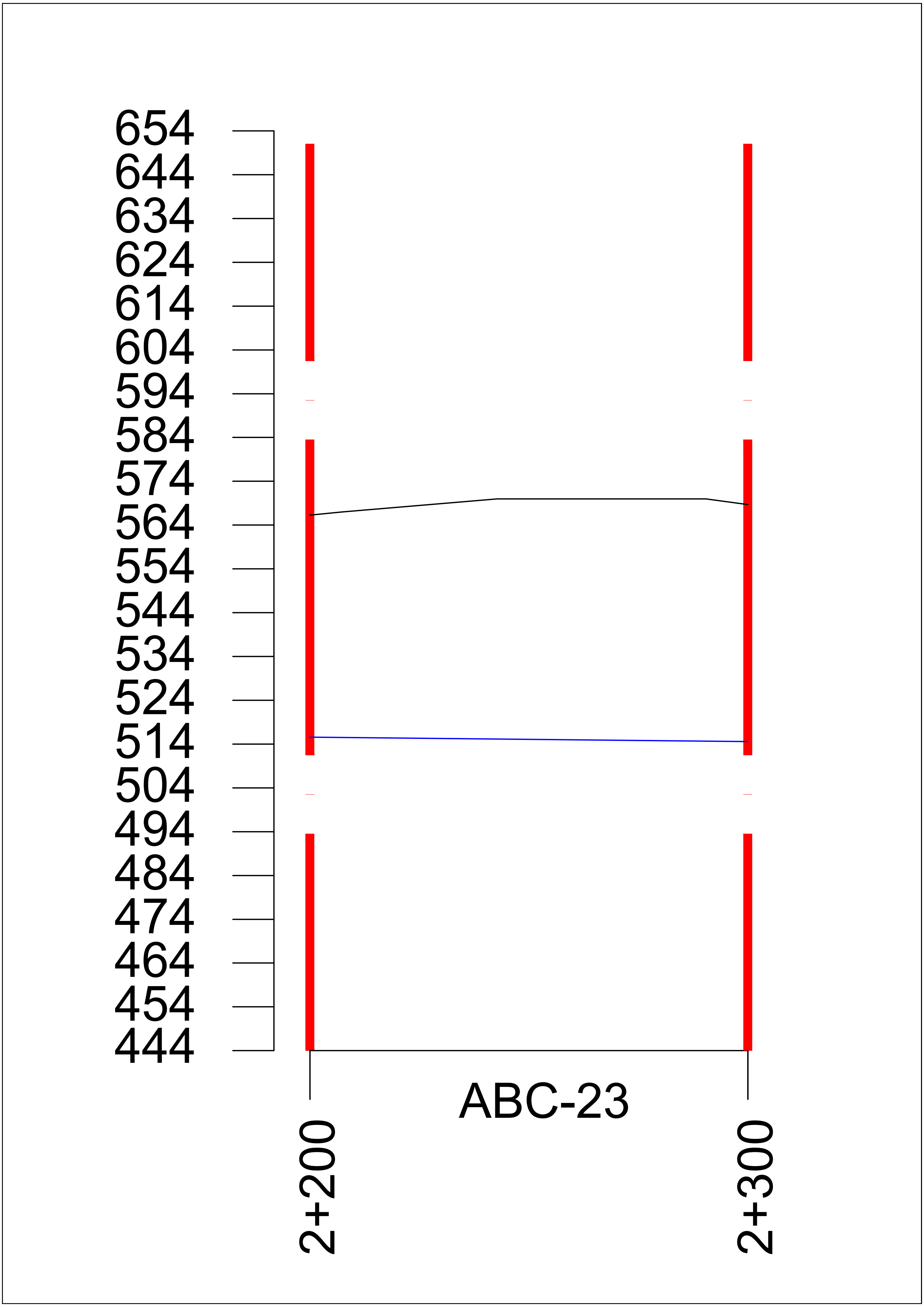

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
1+8001+800
ABC-19
1+900

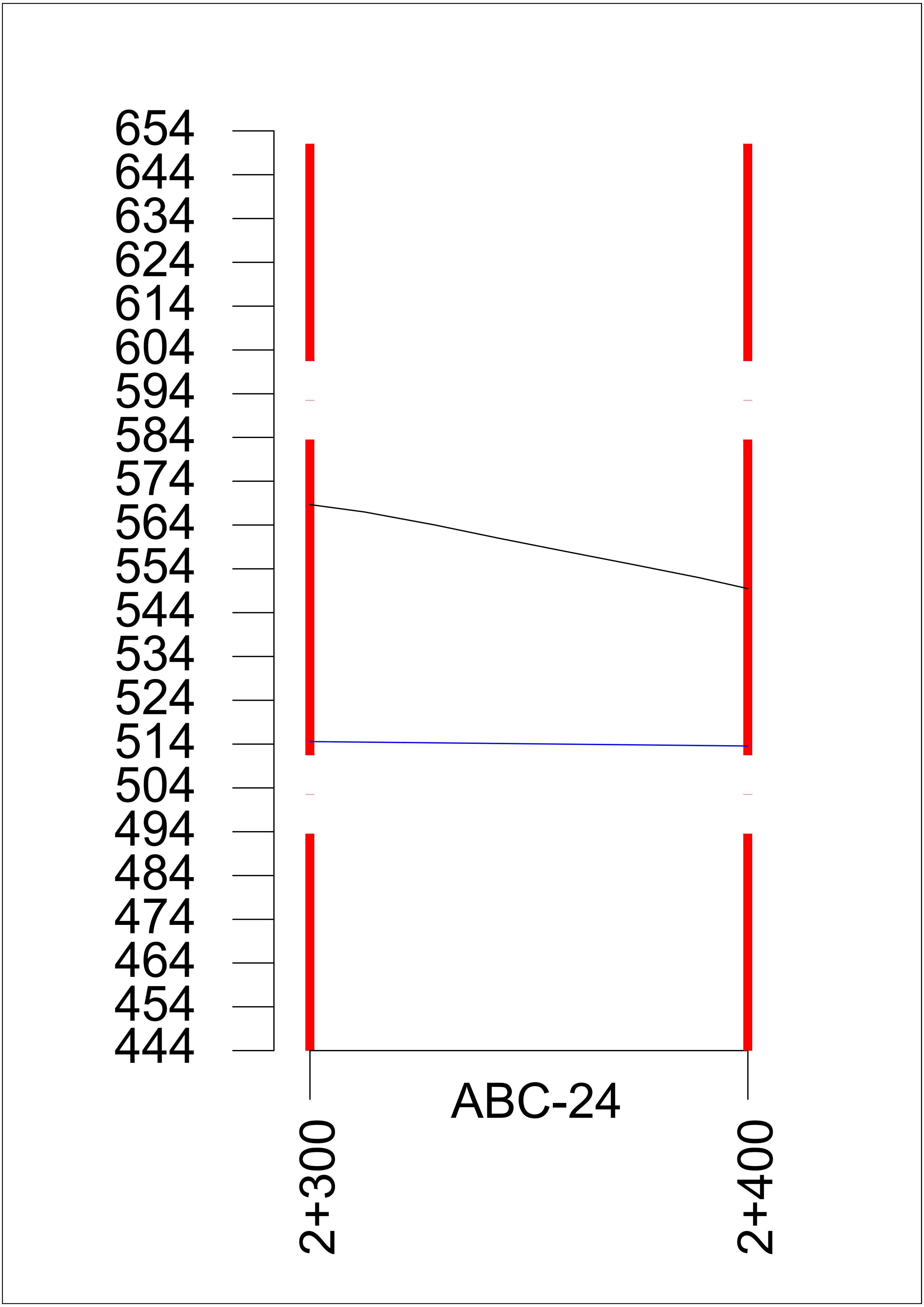

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-20
1+900
2+000

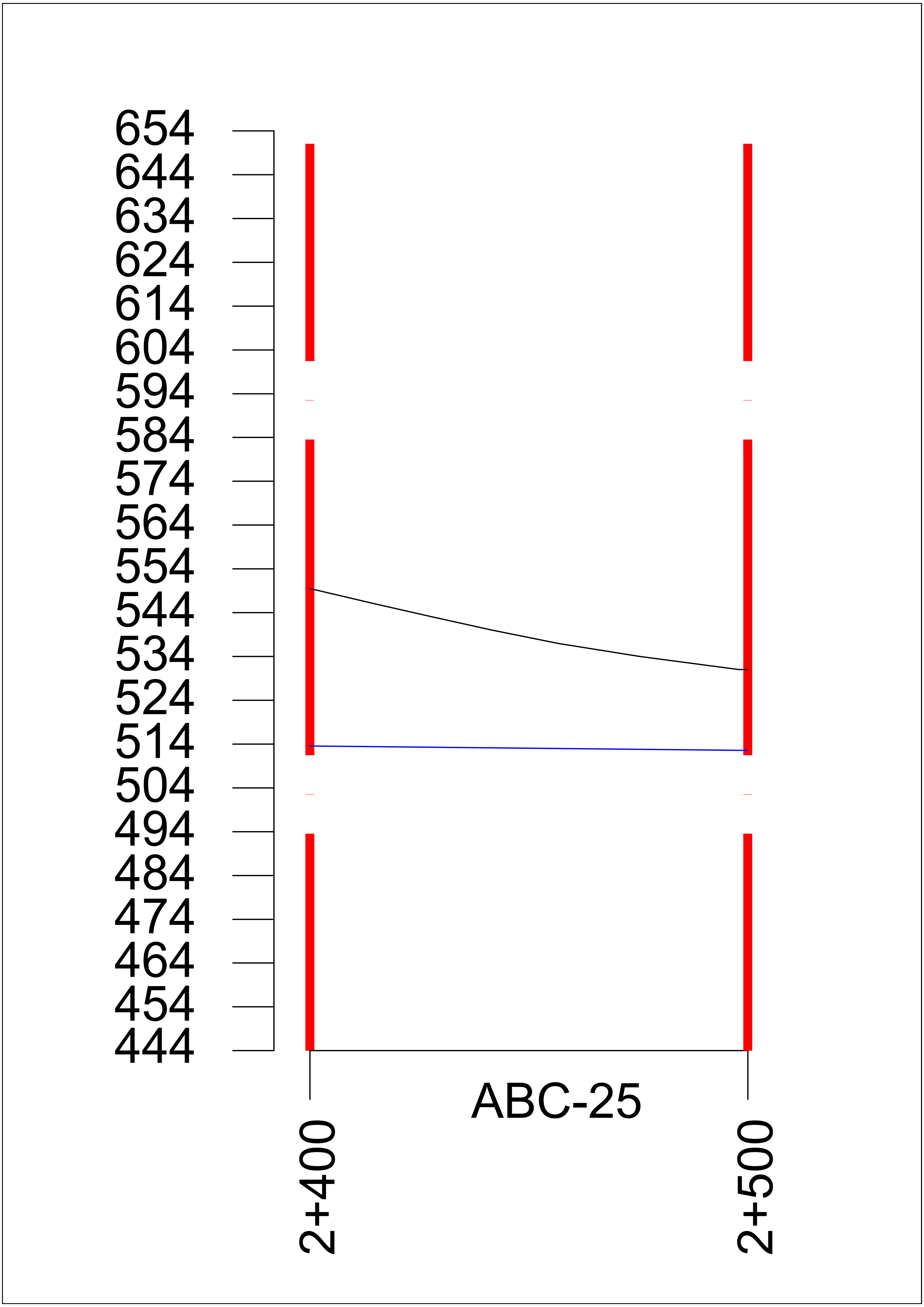


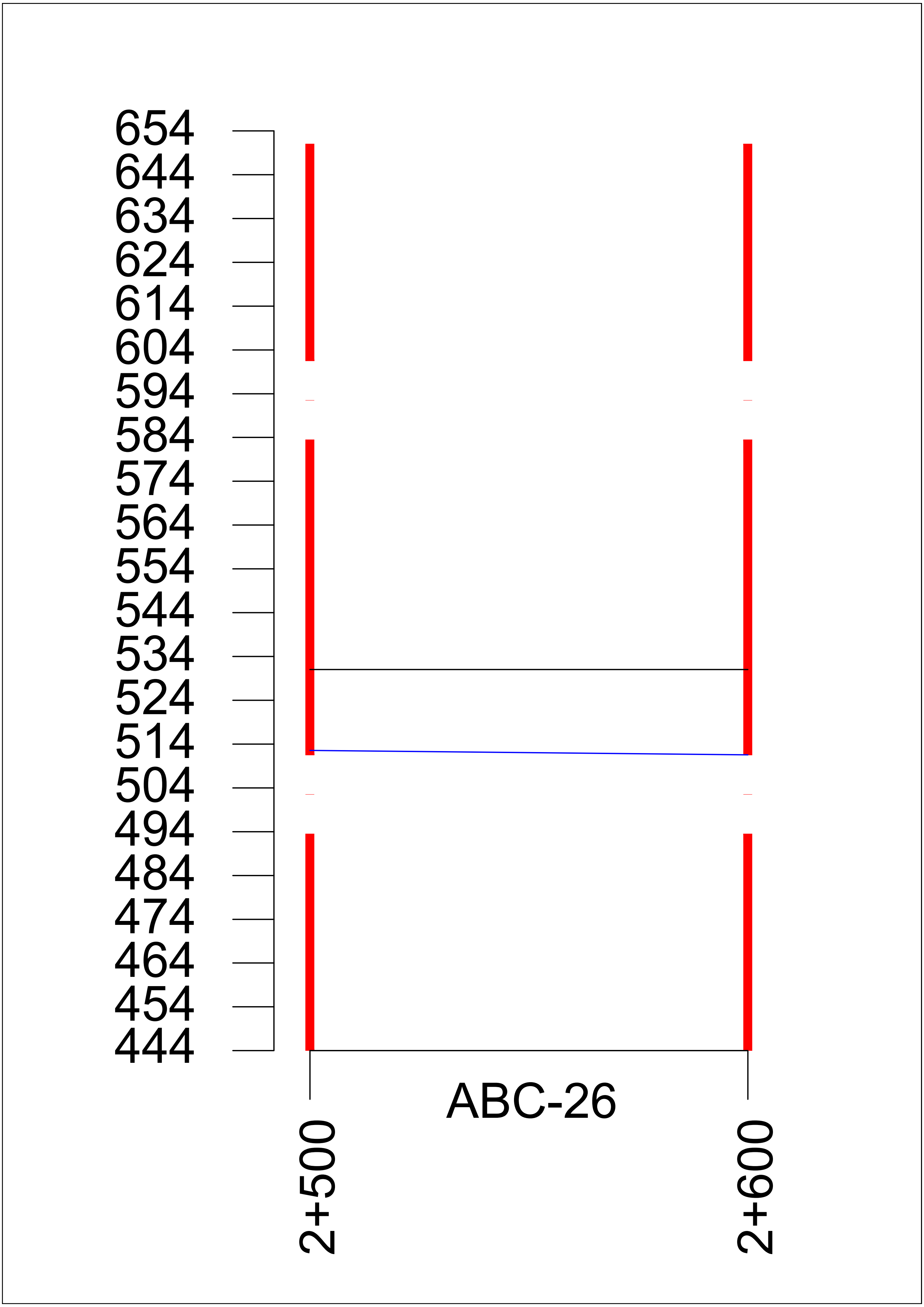
654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-21
2+000
2+100

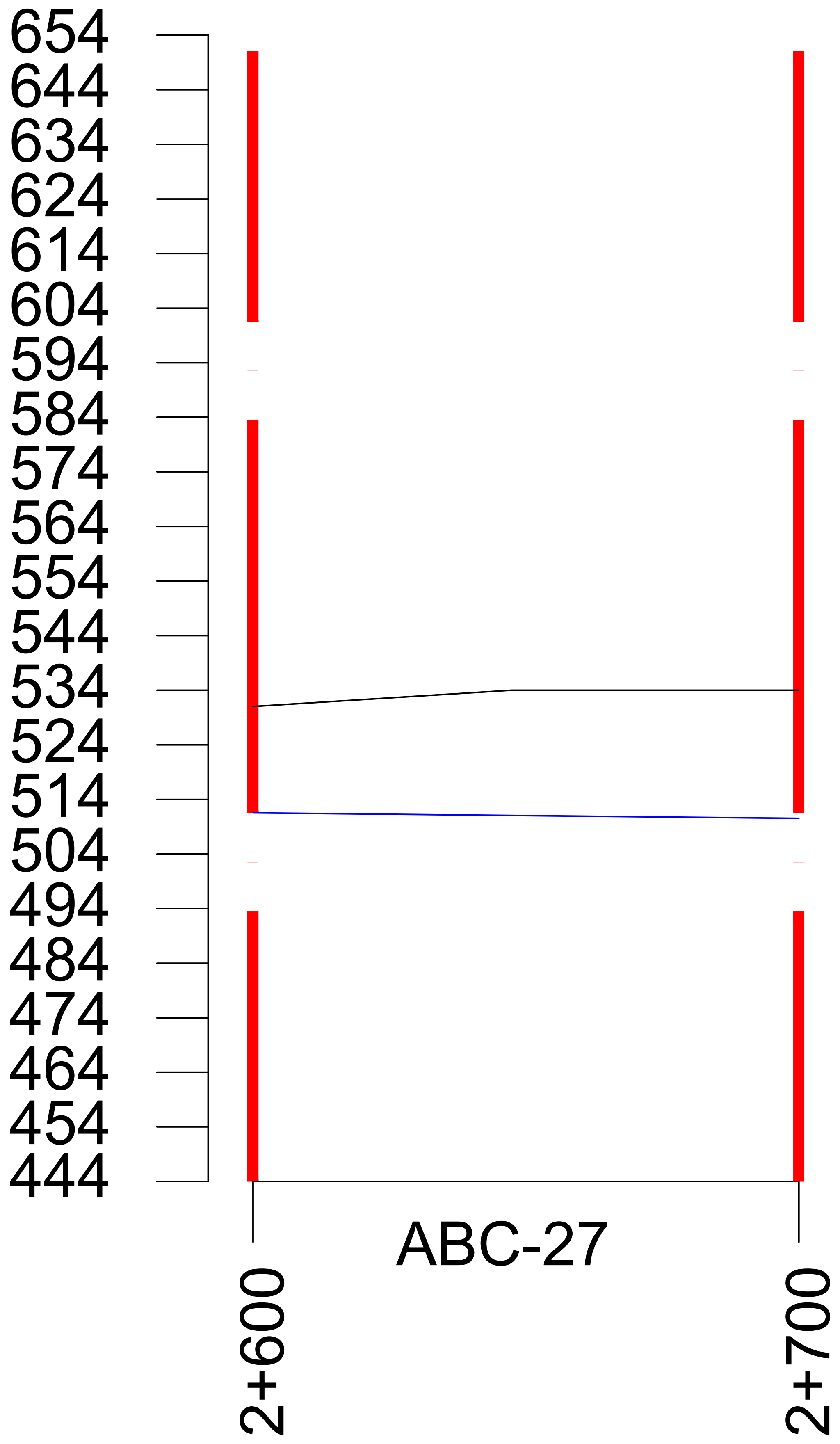

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-22
2+100
2+200

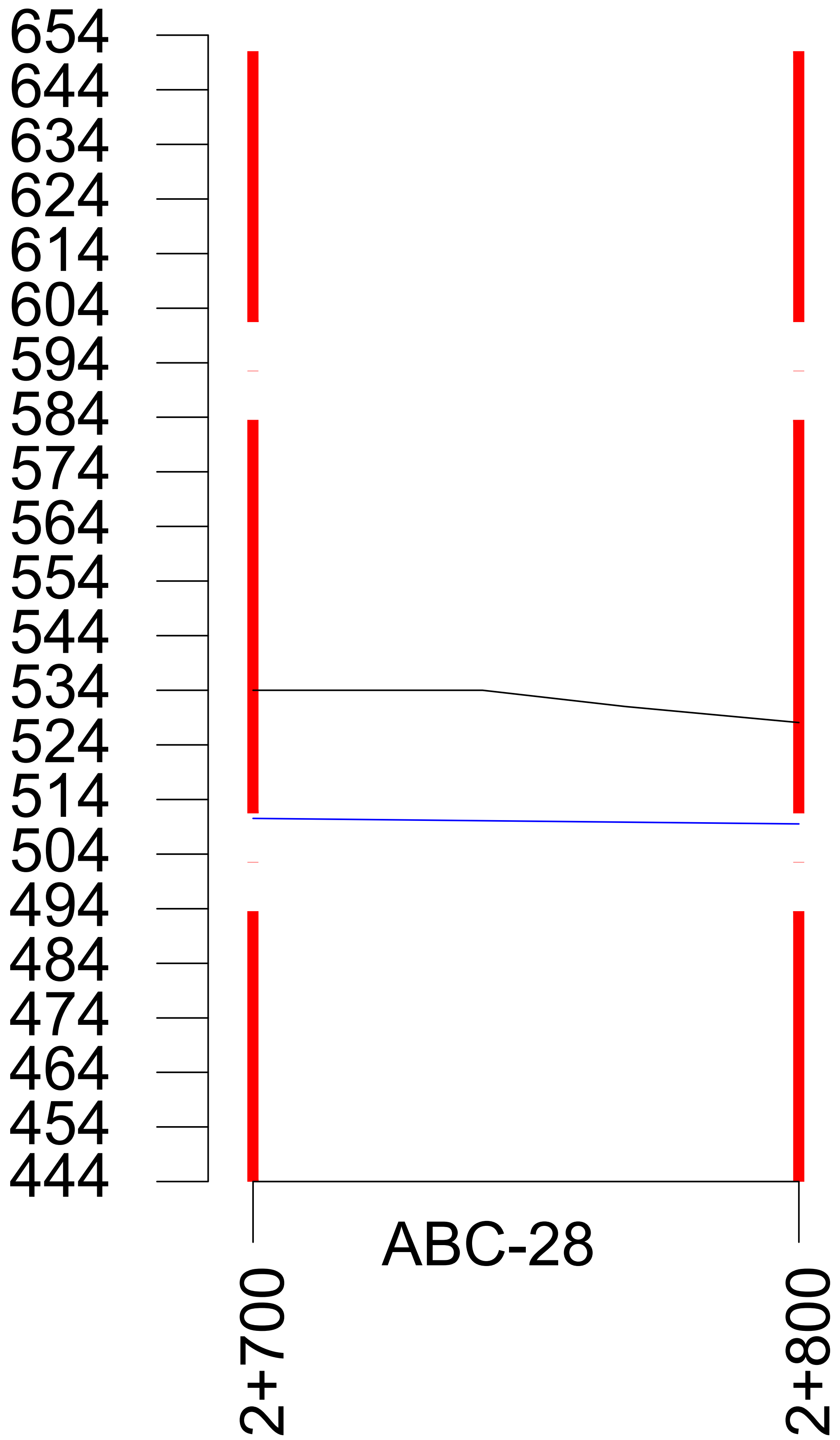

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-23
2+200
2+300

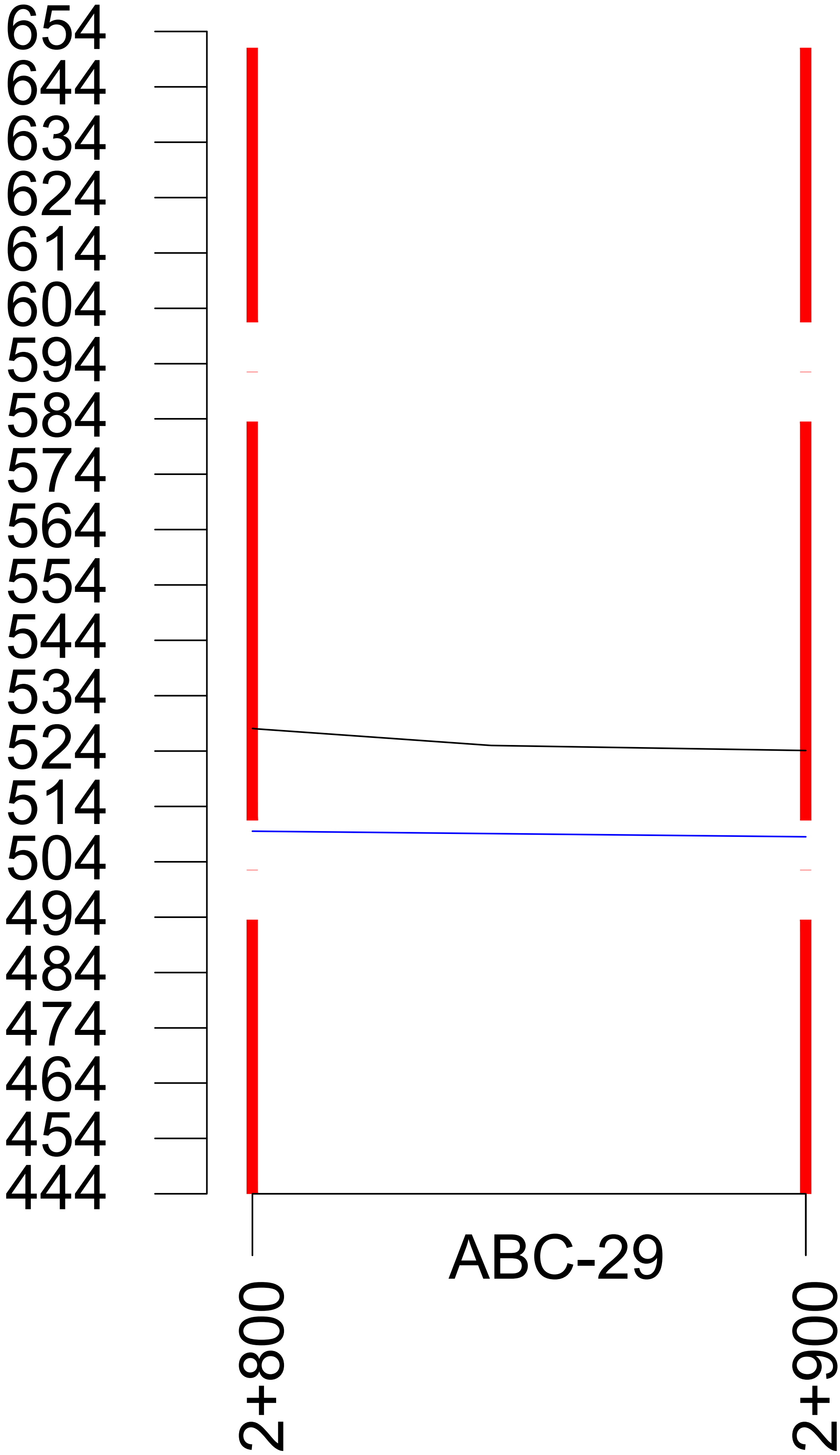

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-24
2+300
2+400

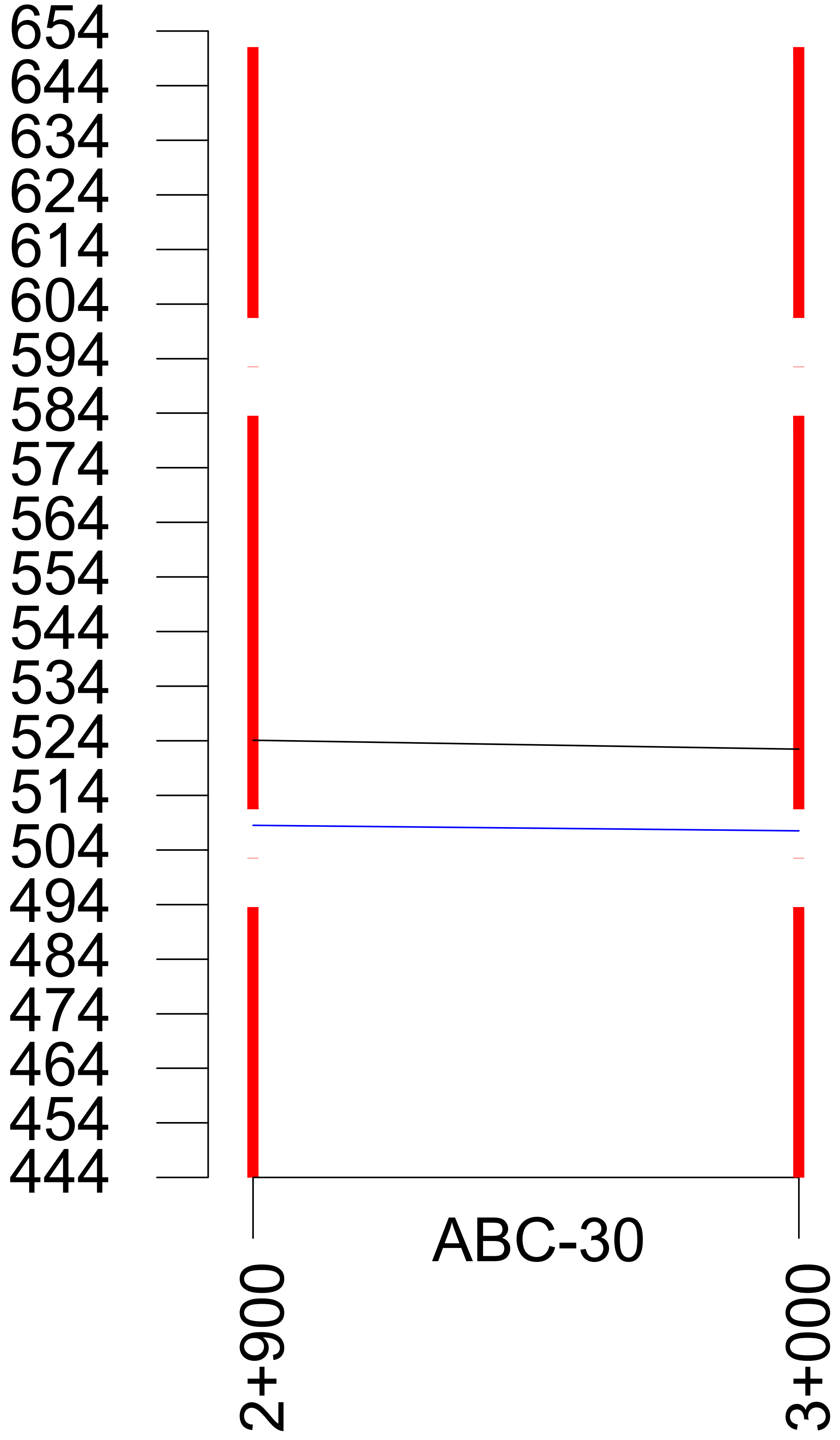

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-25
2+400
2+500

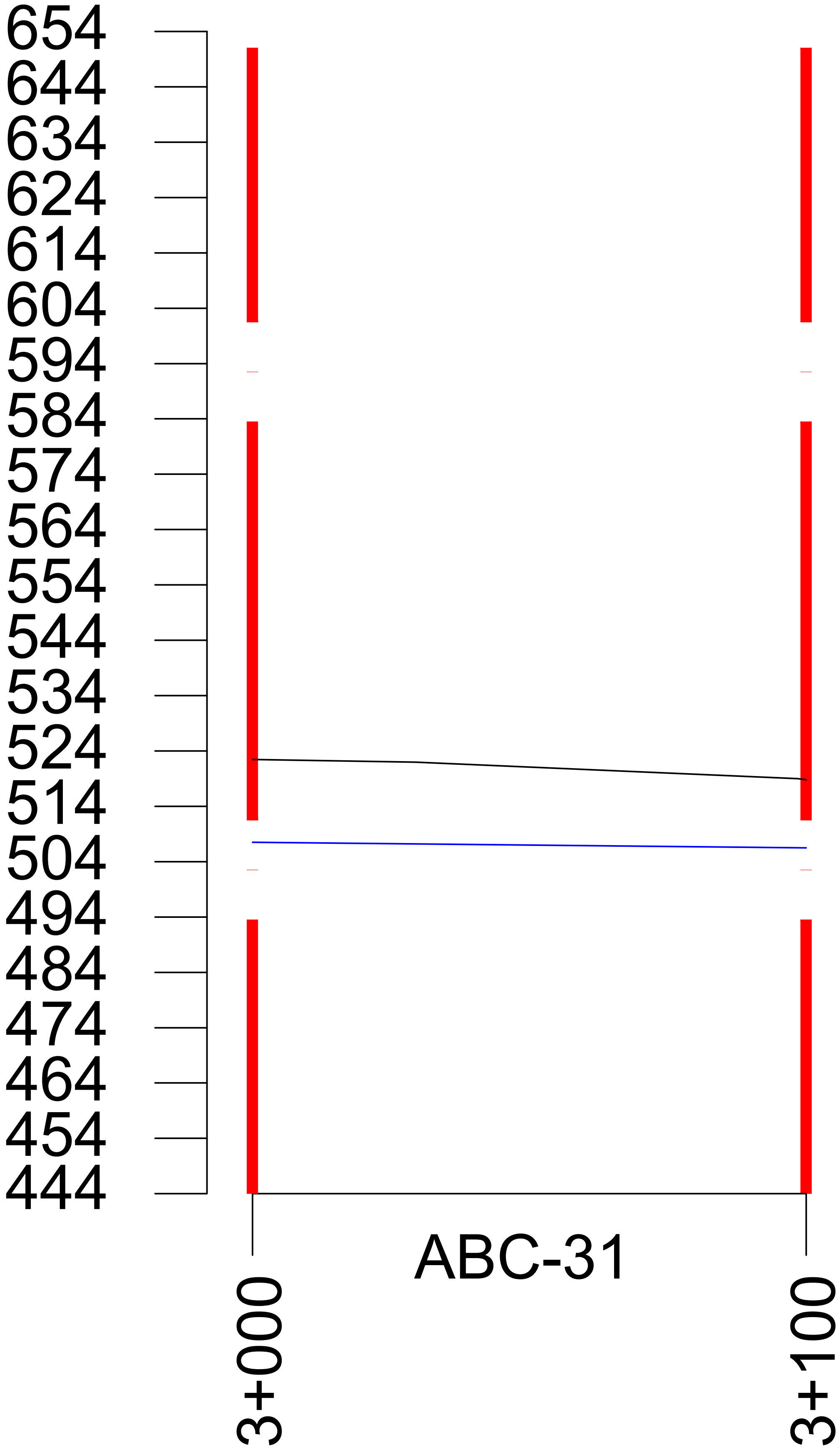

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-26
2+500
2+600

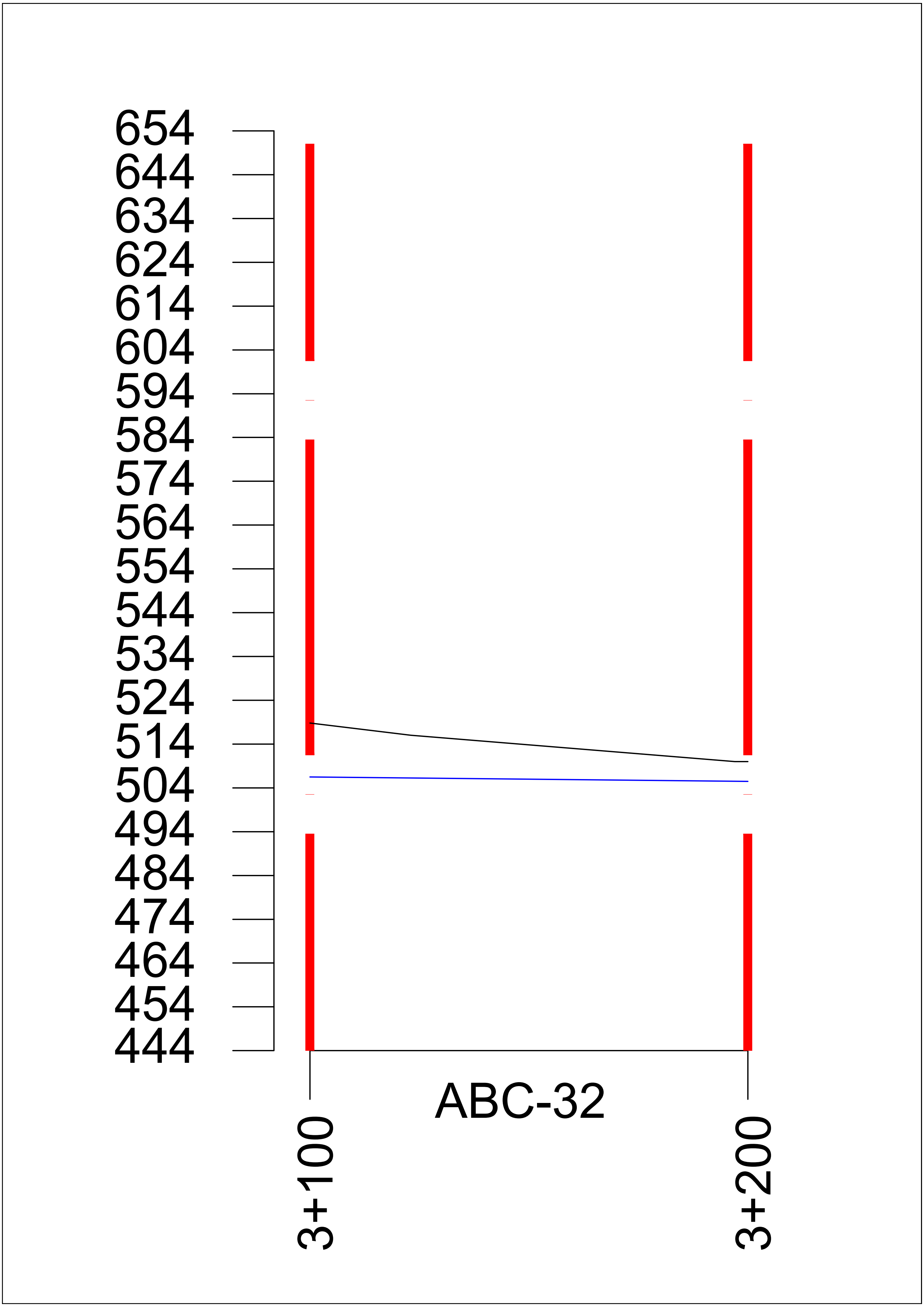

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-27
2+600
2+700

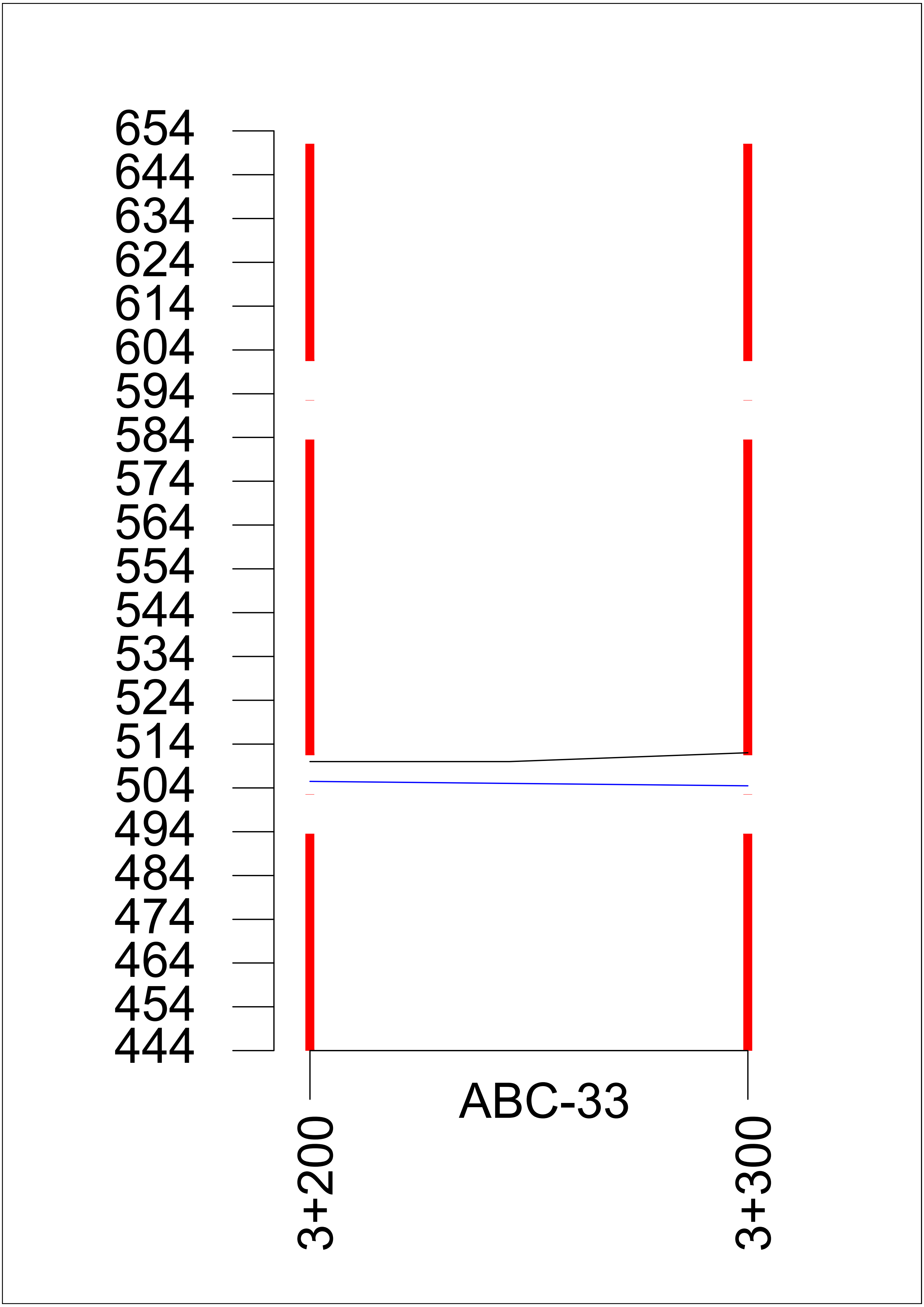

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-28
2+700
2+800

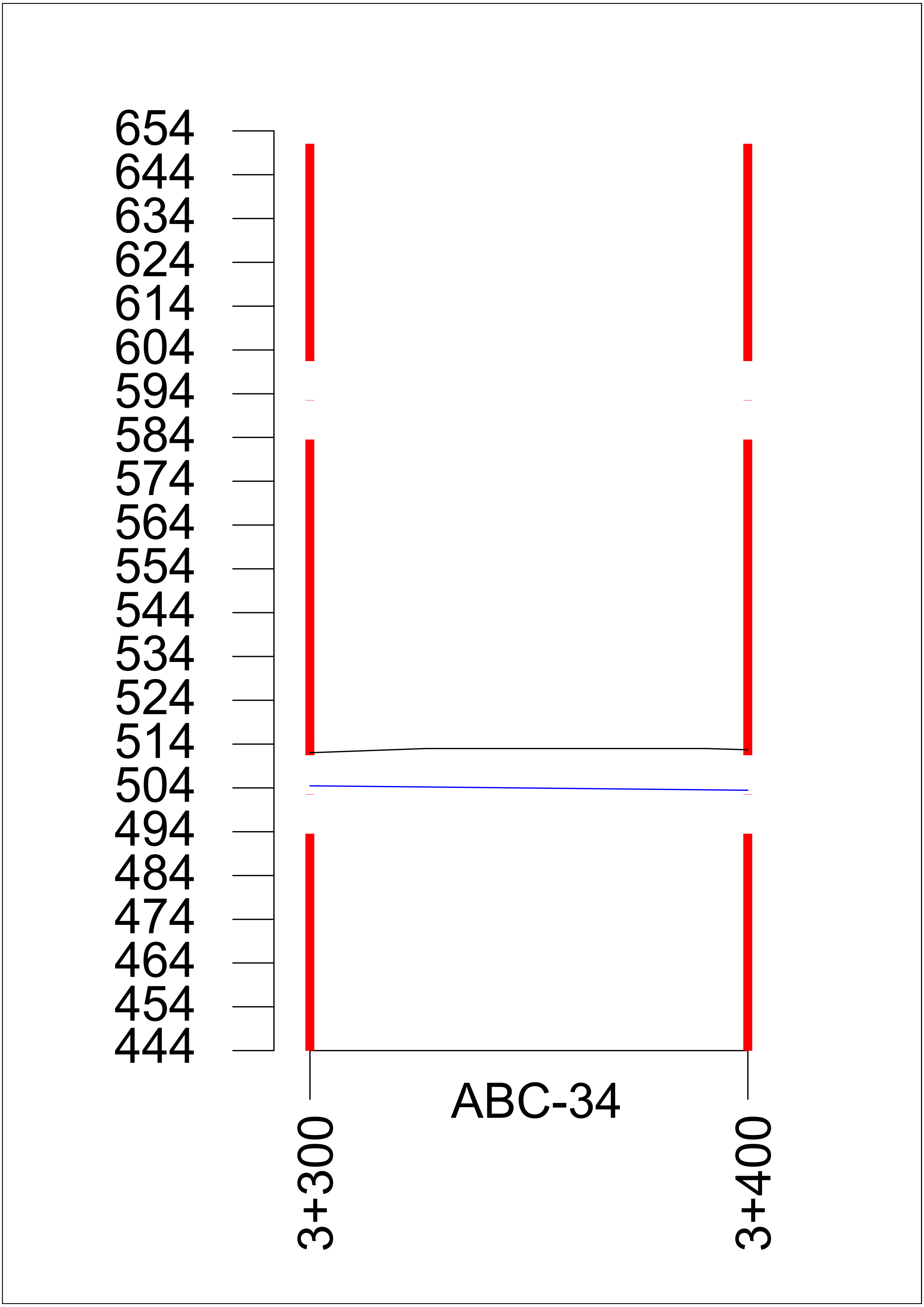

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-29
2+800
2+900

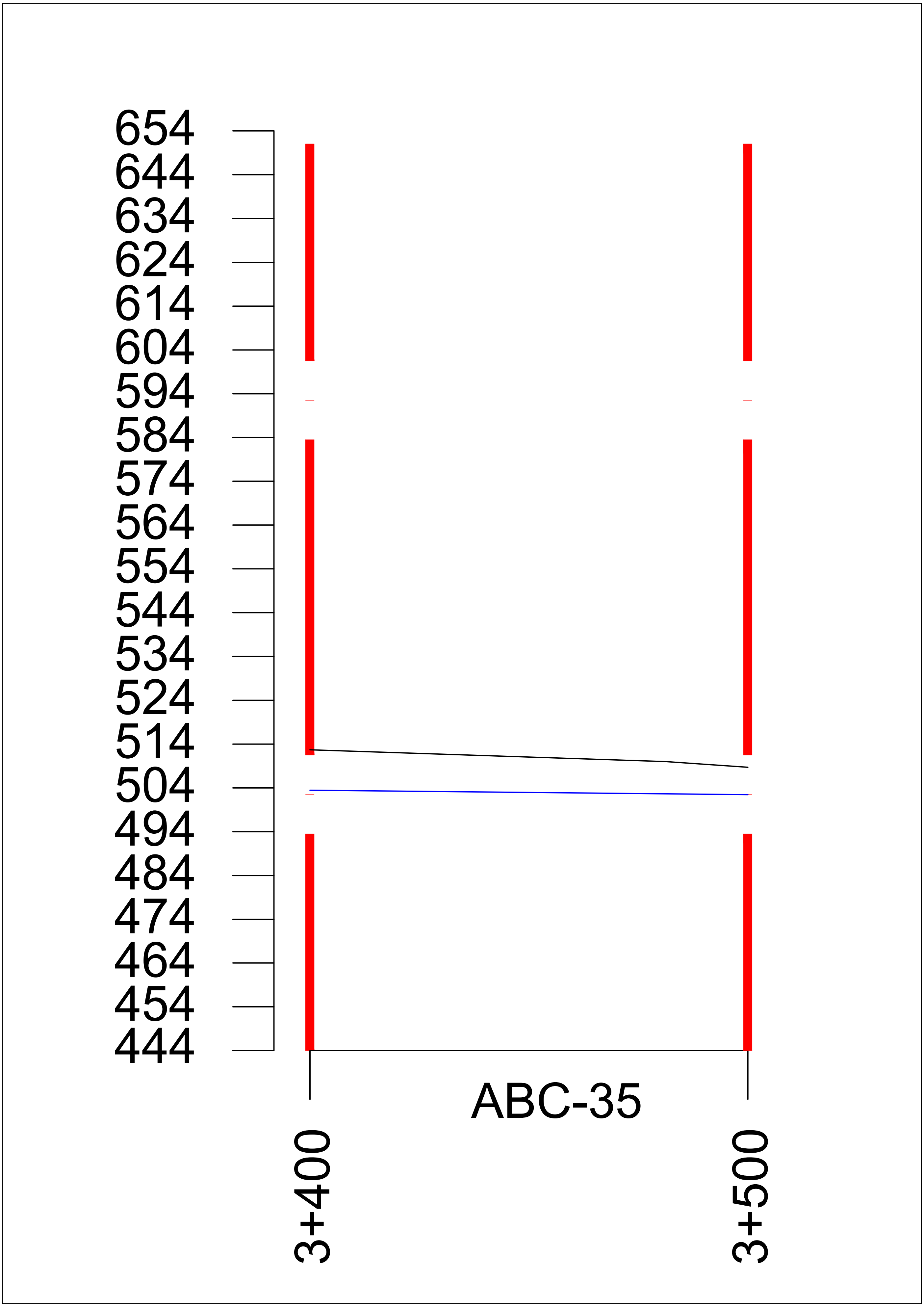

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-30
2+900
3+000

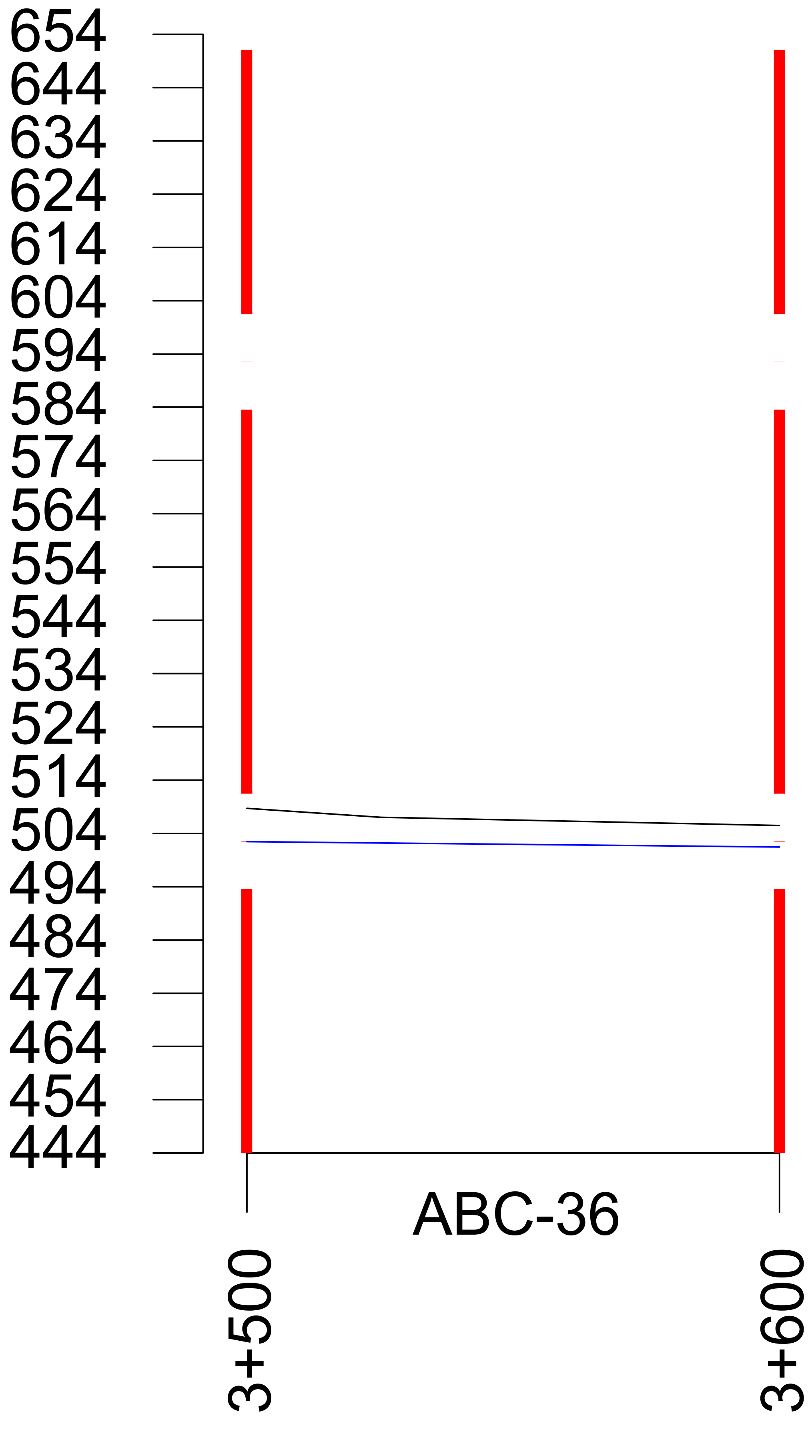

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-31
3+000
3+100

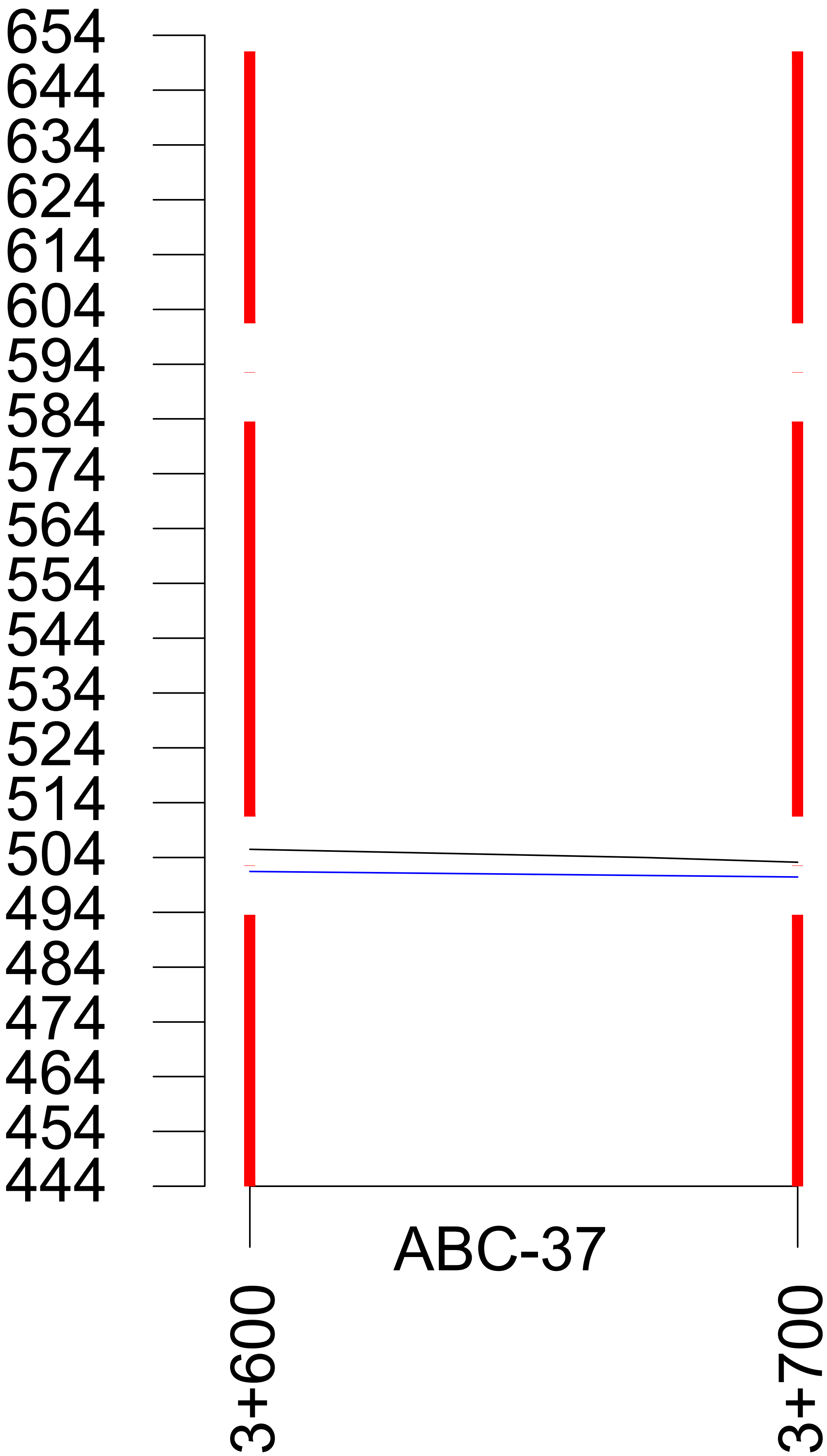

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-32
3+100
3+200

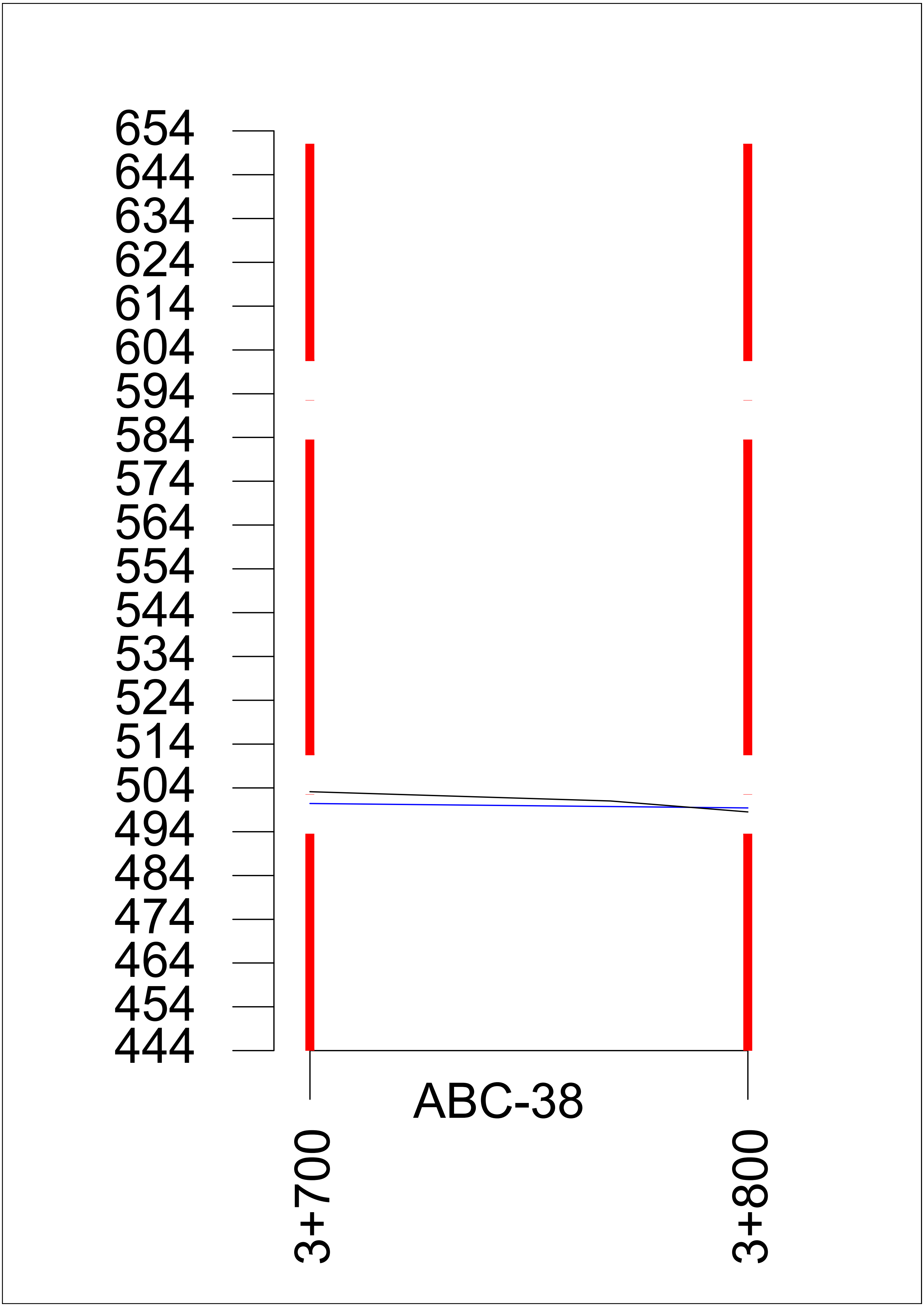

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-33
3+200
3+300

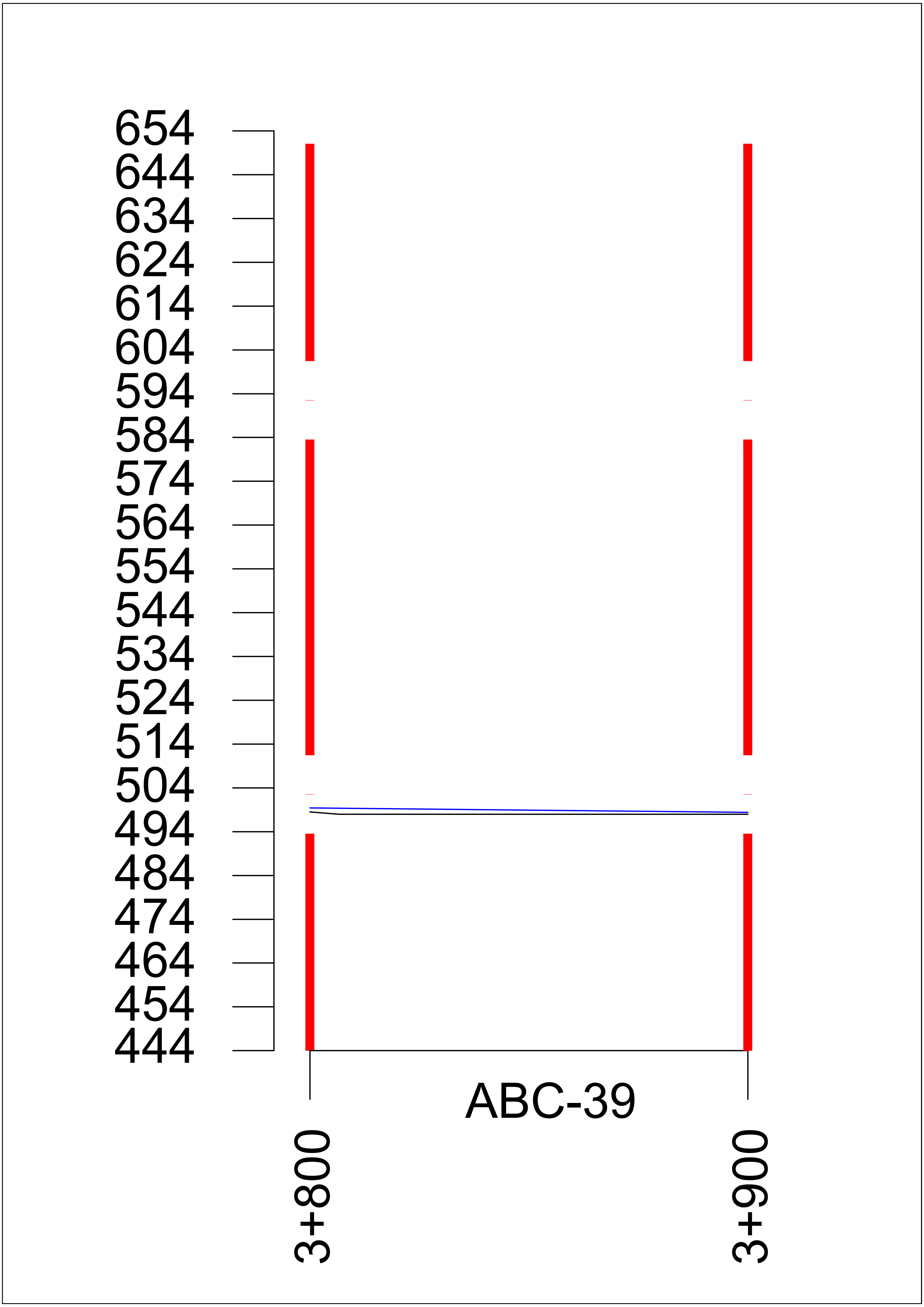

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-34
3+300
3+400

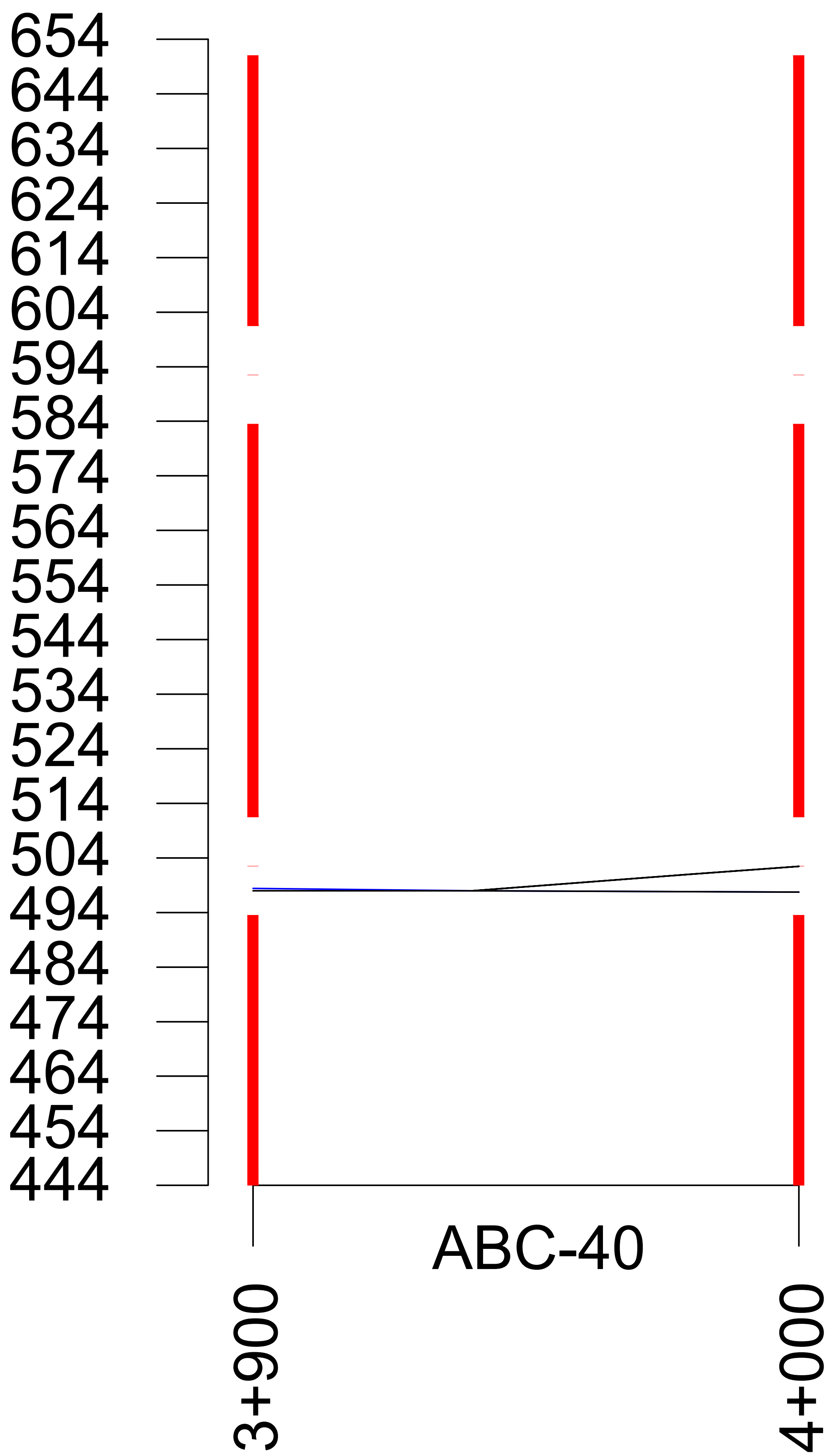

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-35
3+400
3+500

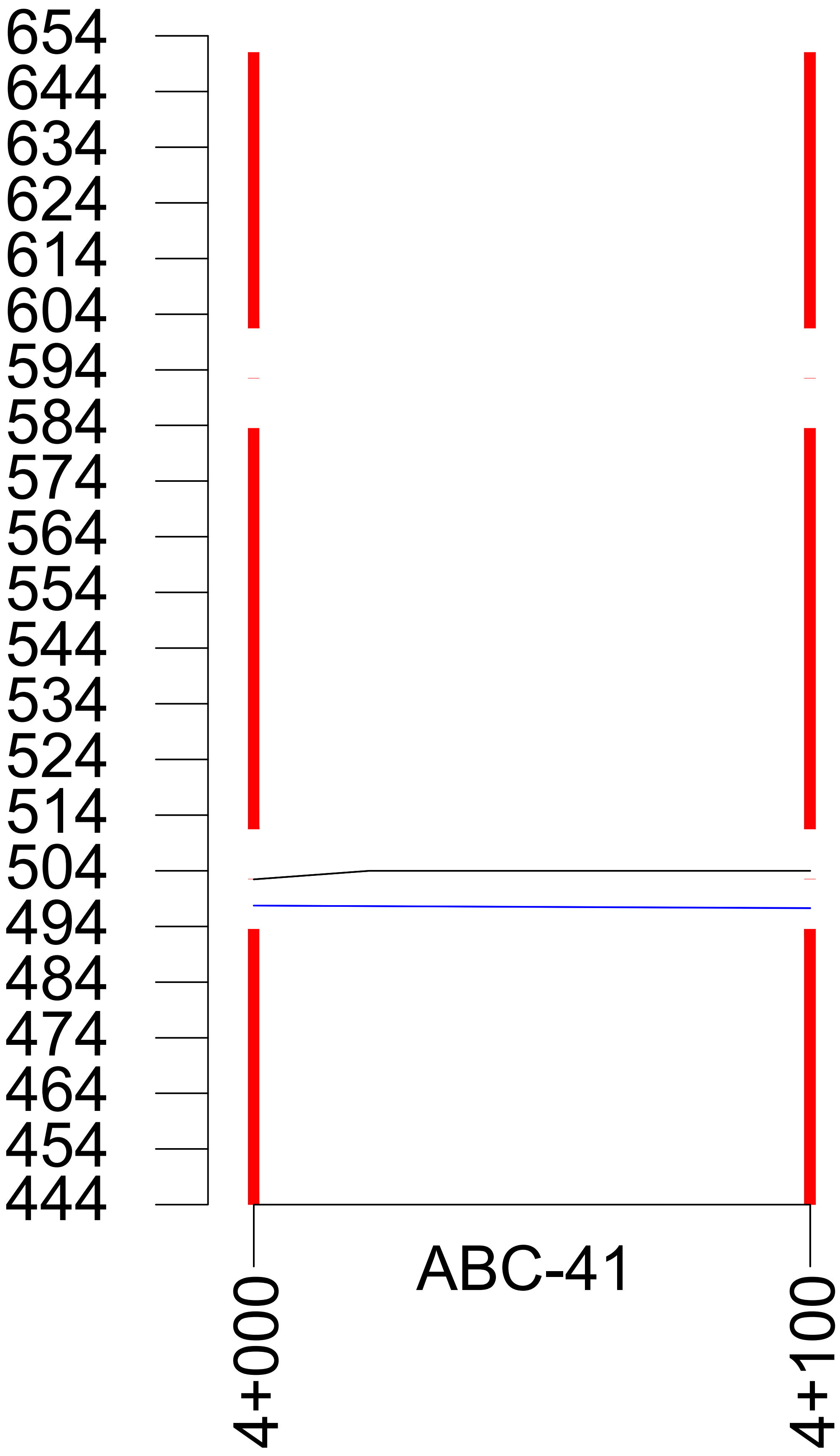

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-36
3+500
3+600

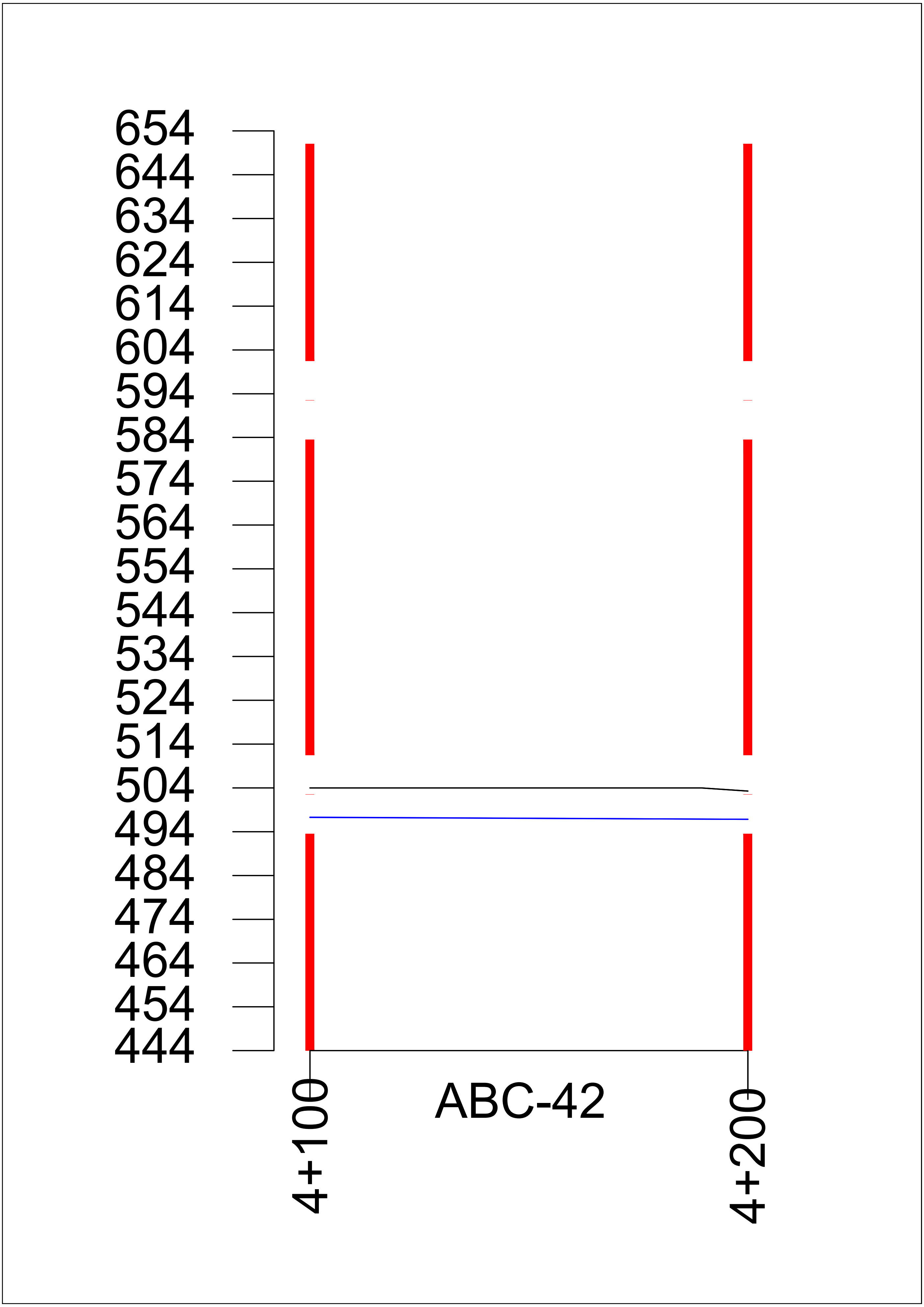

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-37
3+600
3+700


654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-38
3+700
3+800

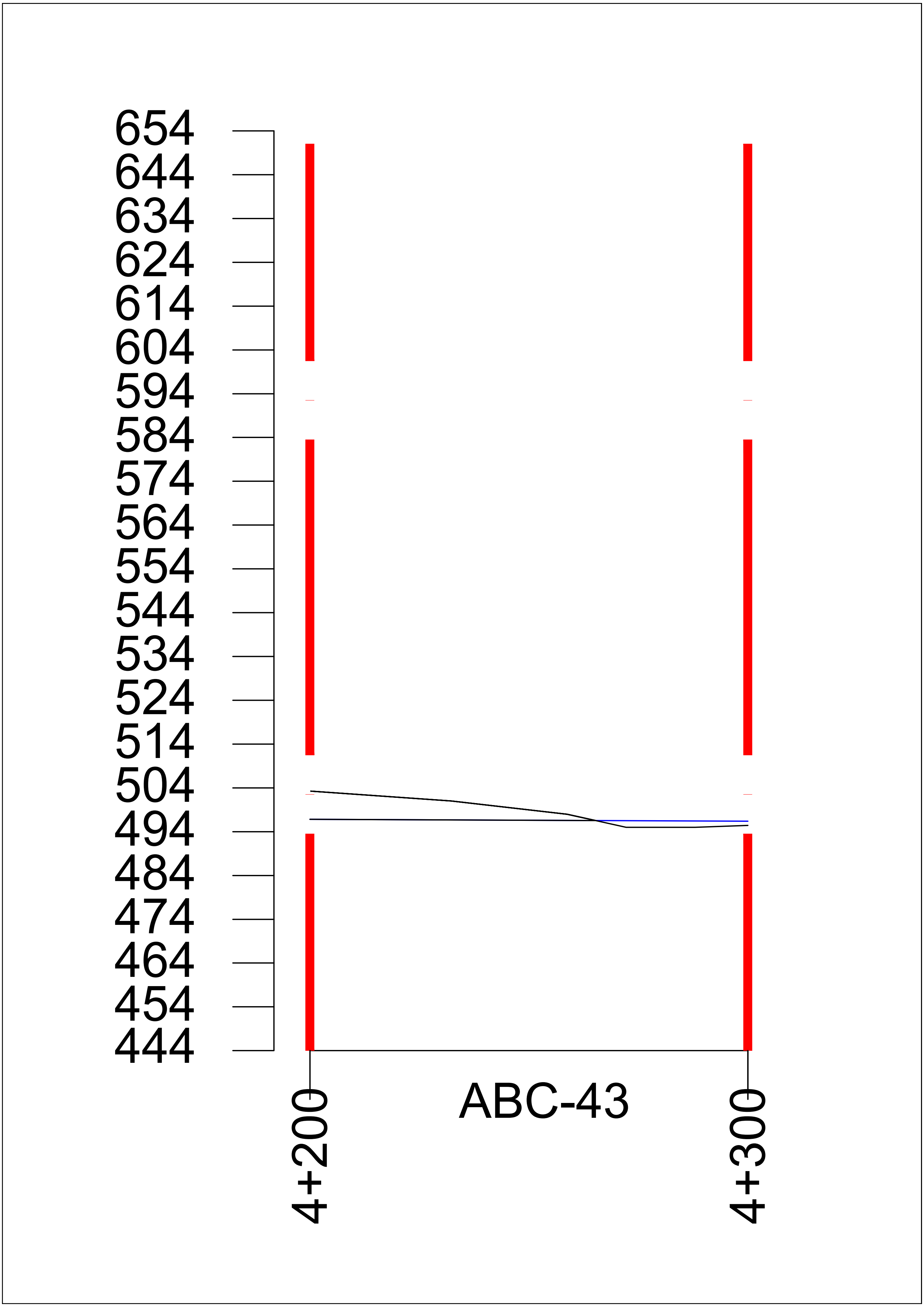

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-39
3+800
3+900

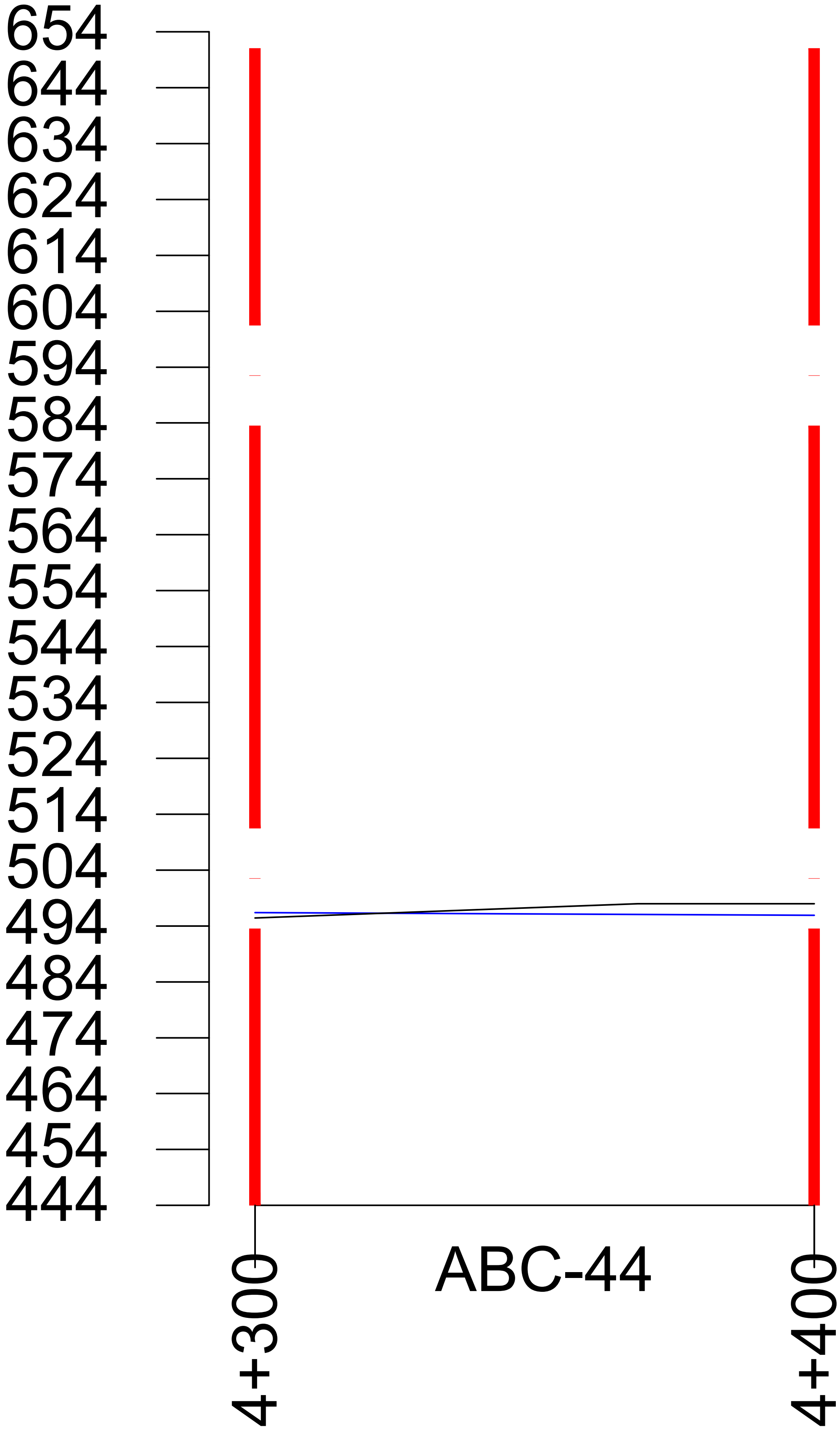

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-40
3+900
4+000

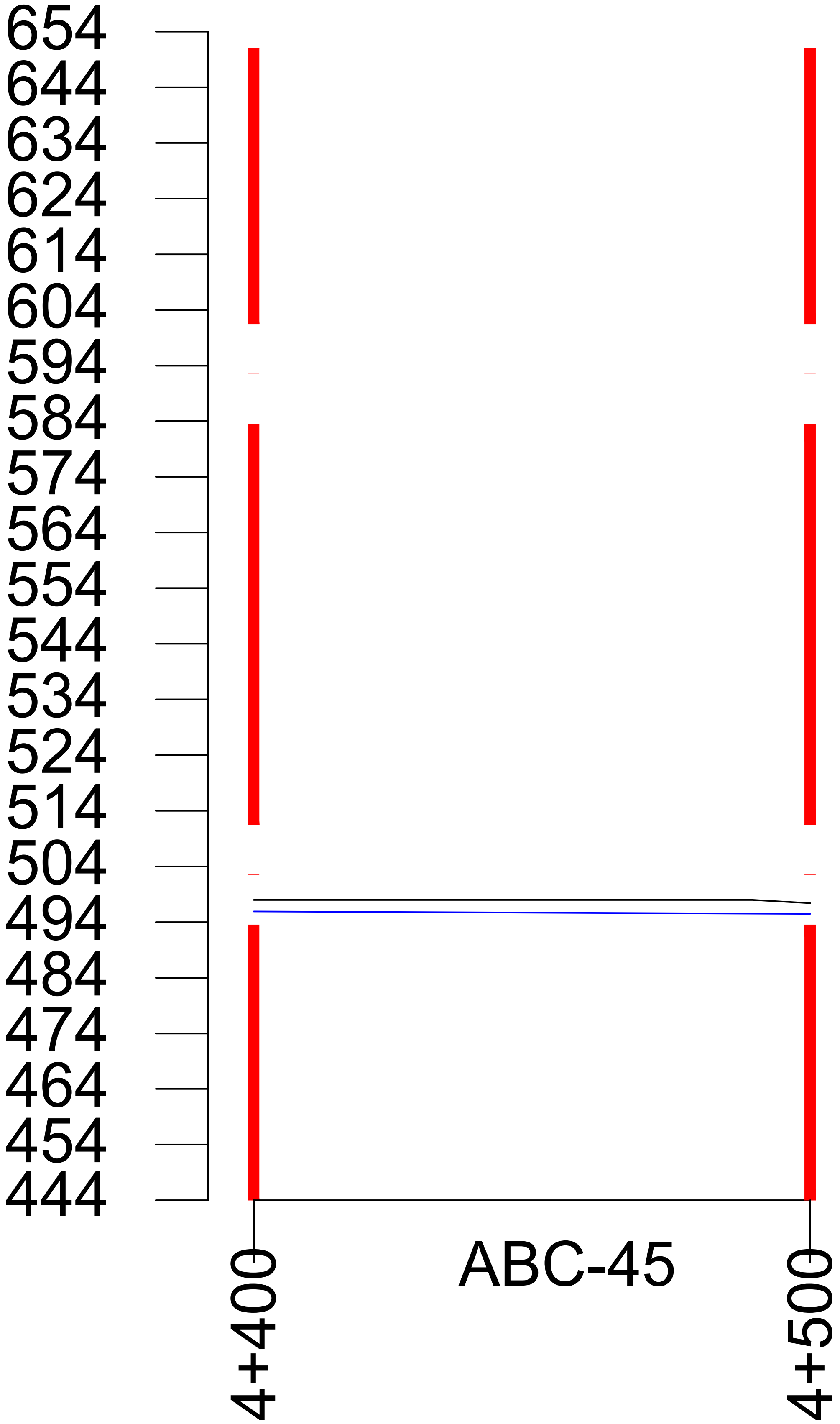

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-41
4+000
4+100

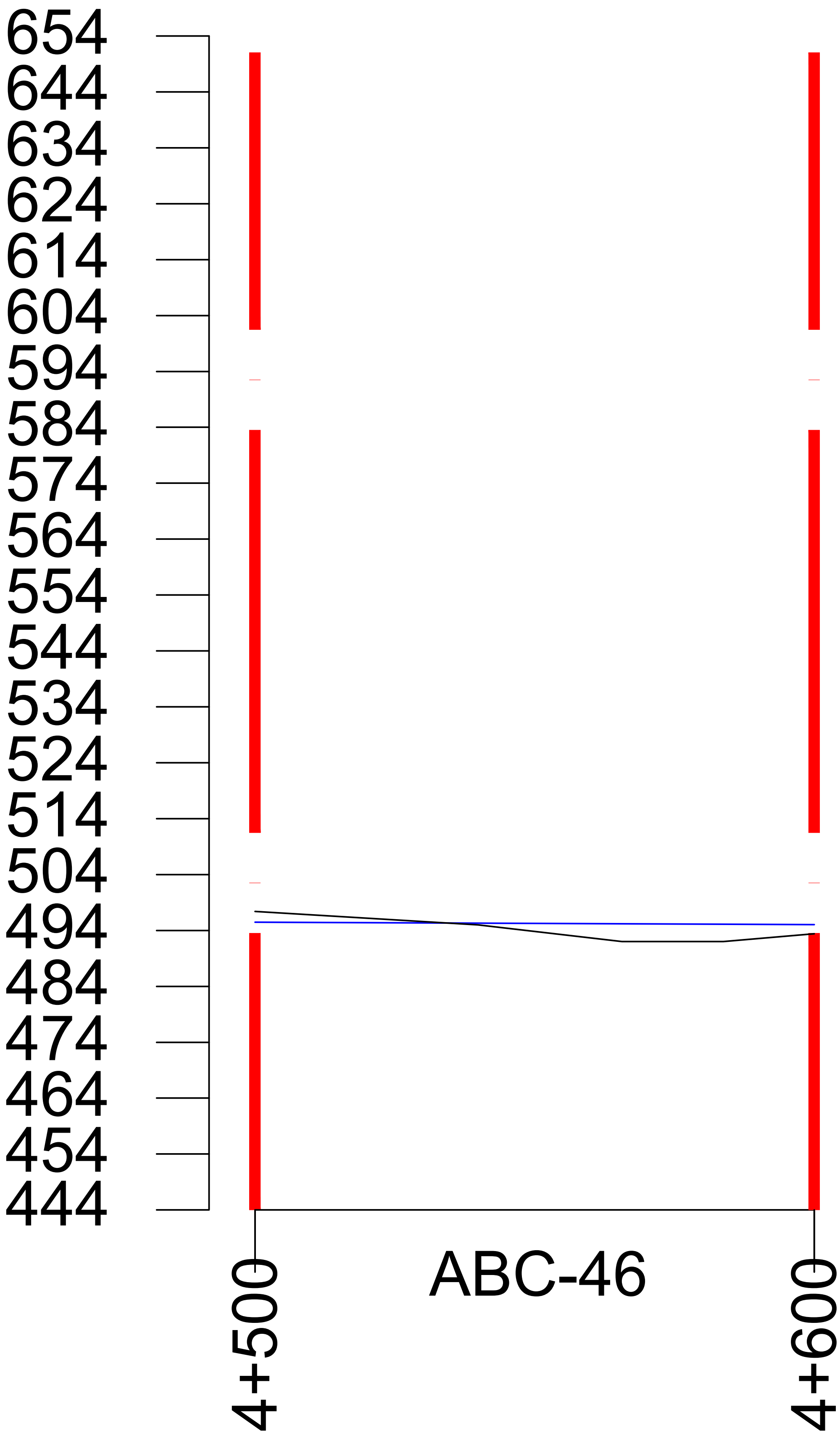


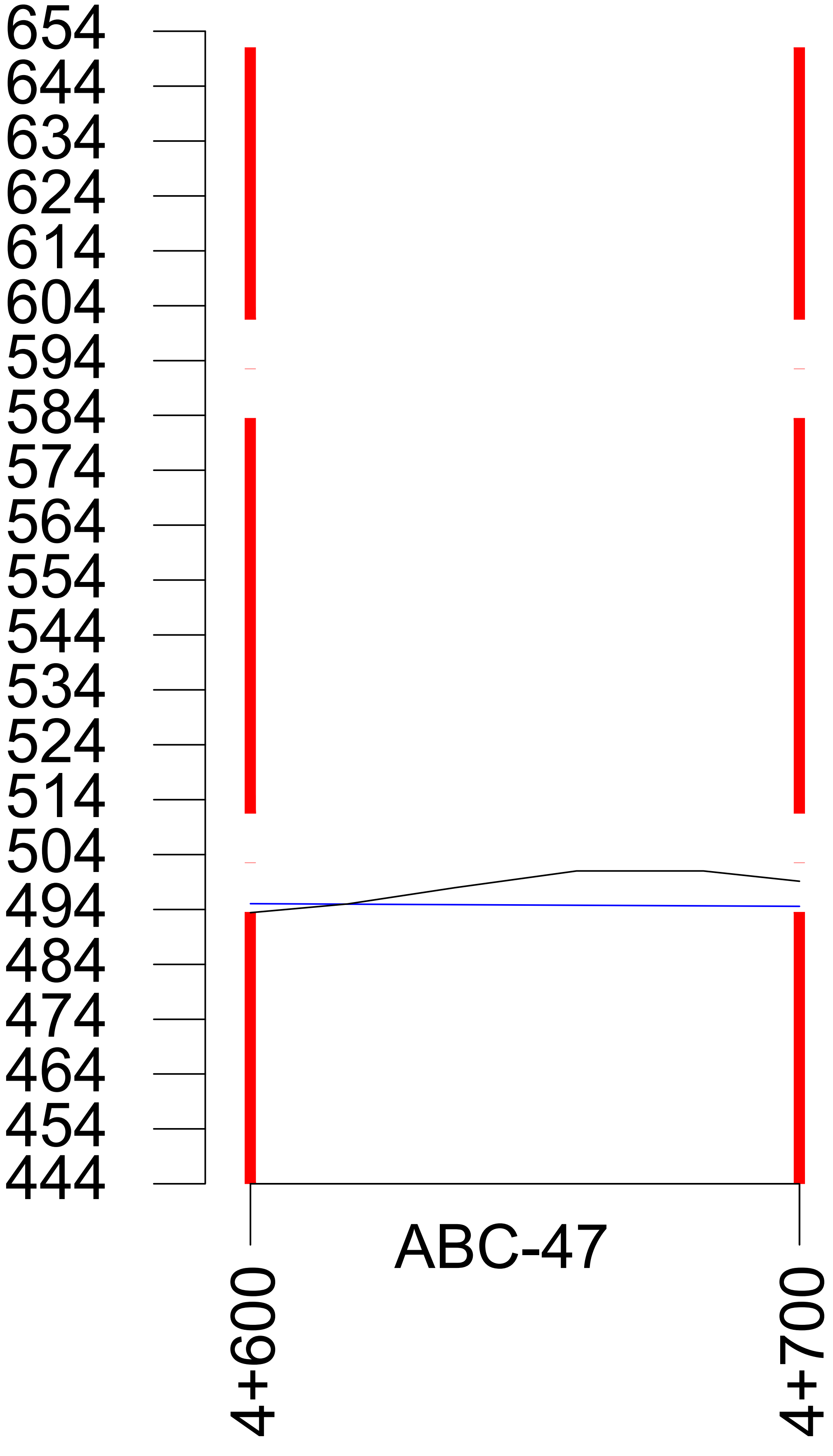
654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
4+100
ABC-42
4+200

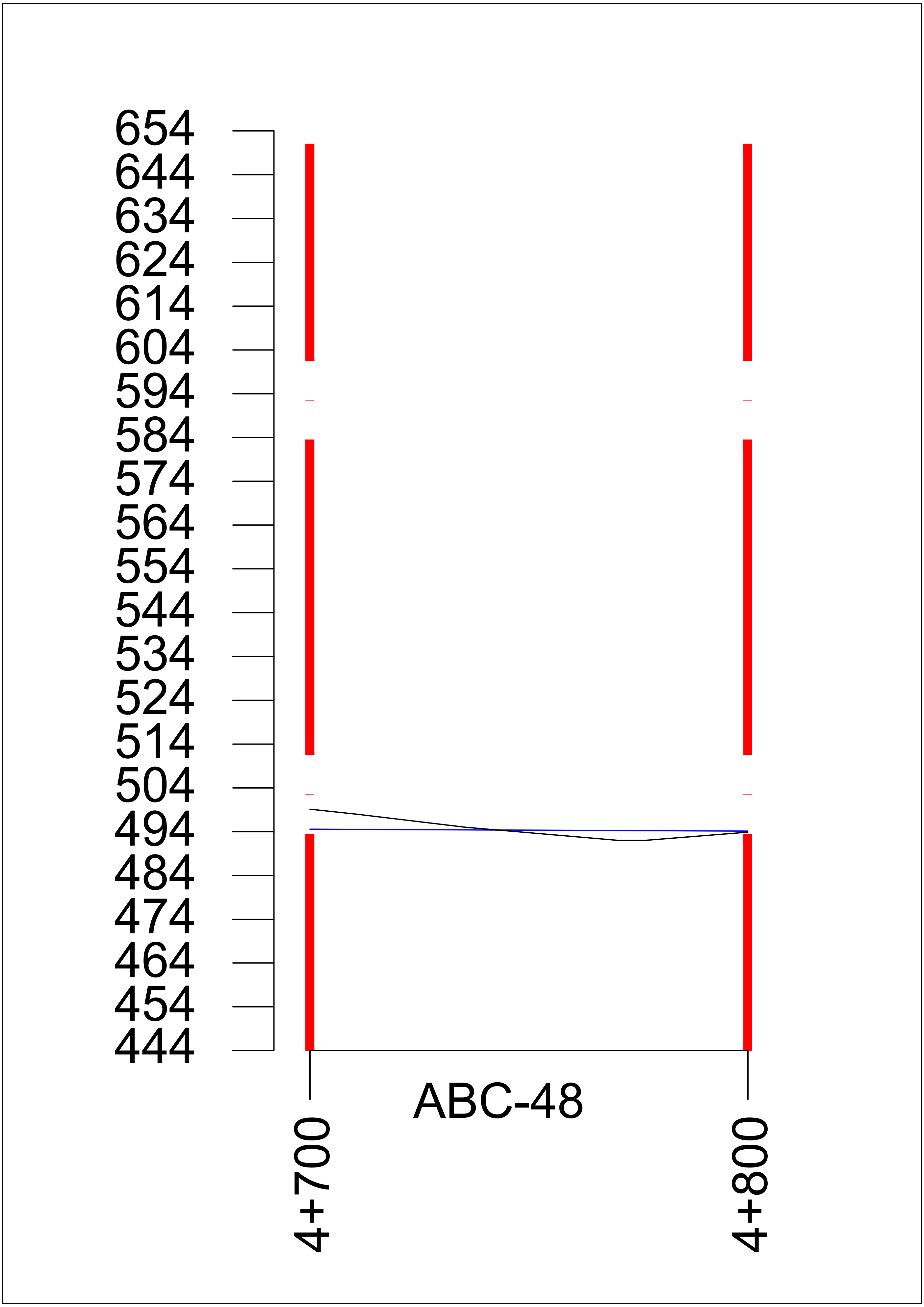

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-43
4+200
4+300

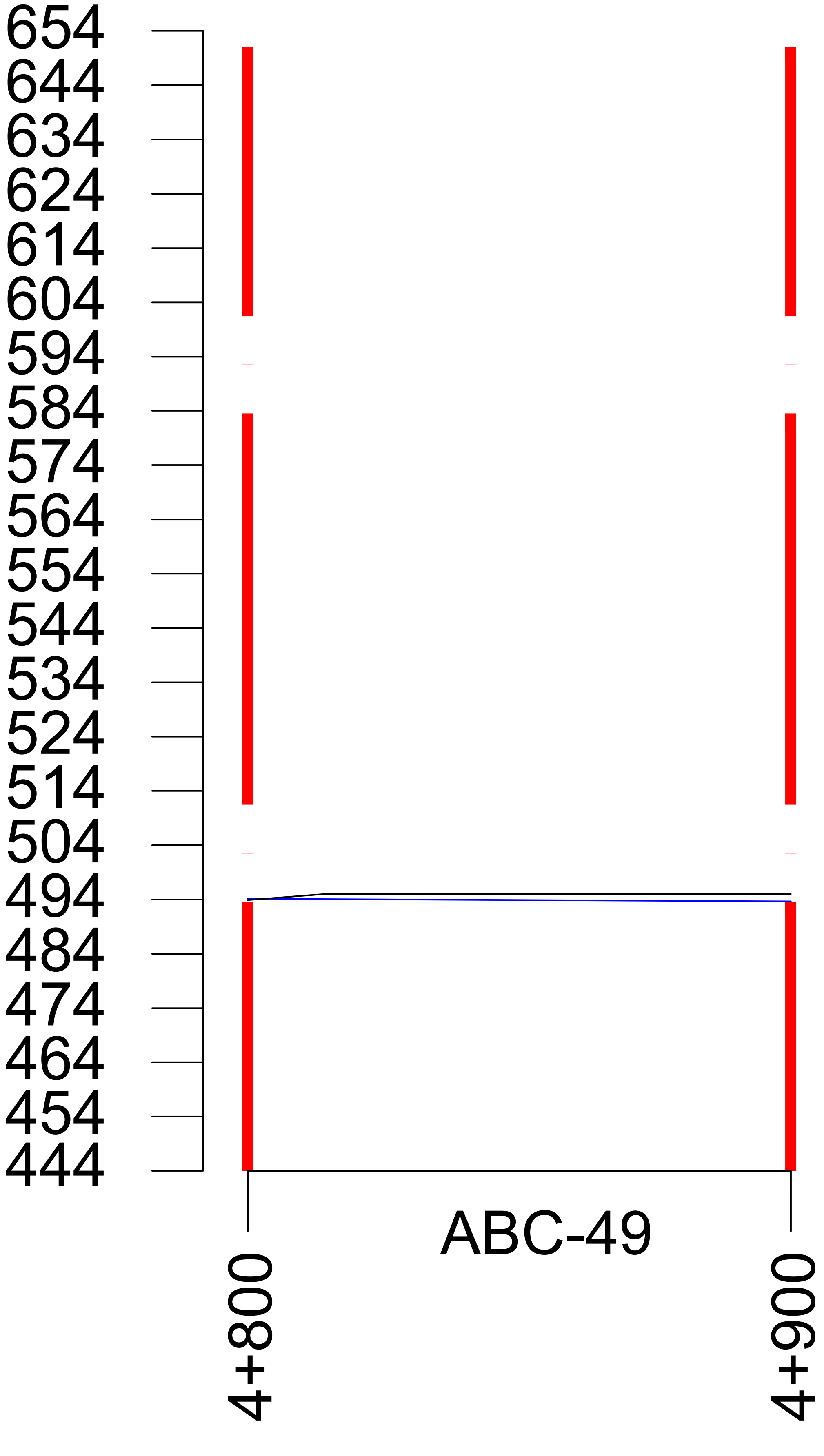

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
4+300
ABC-44
4+400


654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-45
4+400
4+500

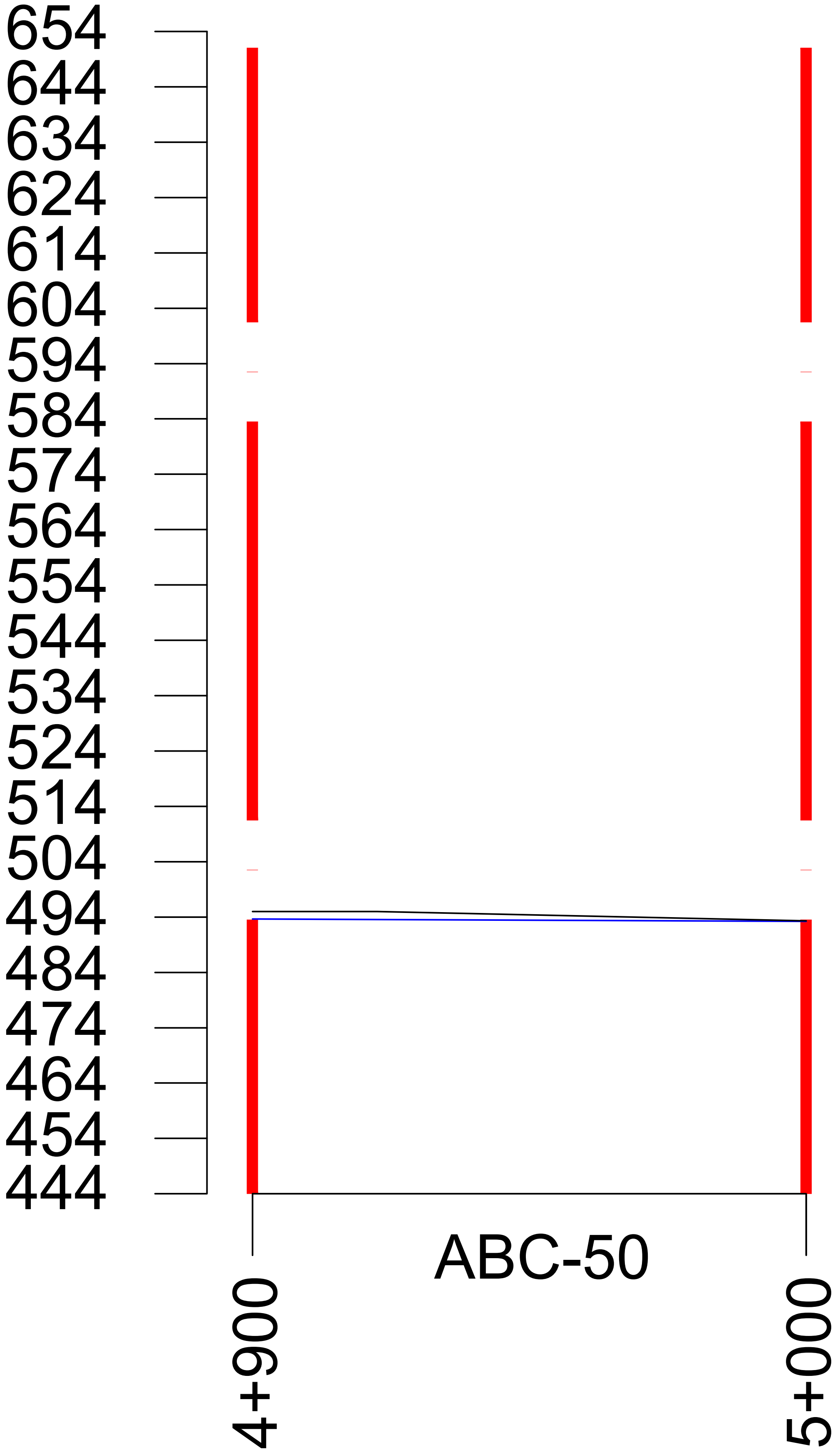

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-46
4+500
4+600

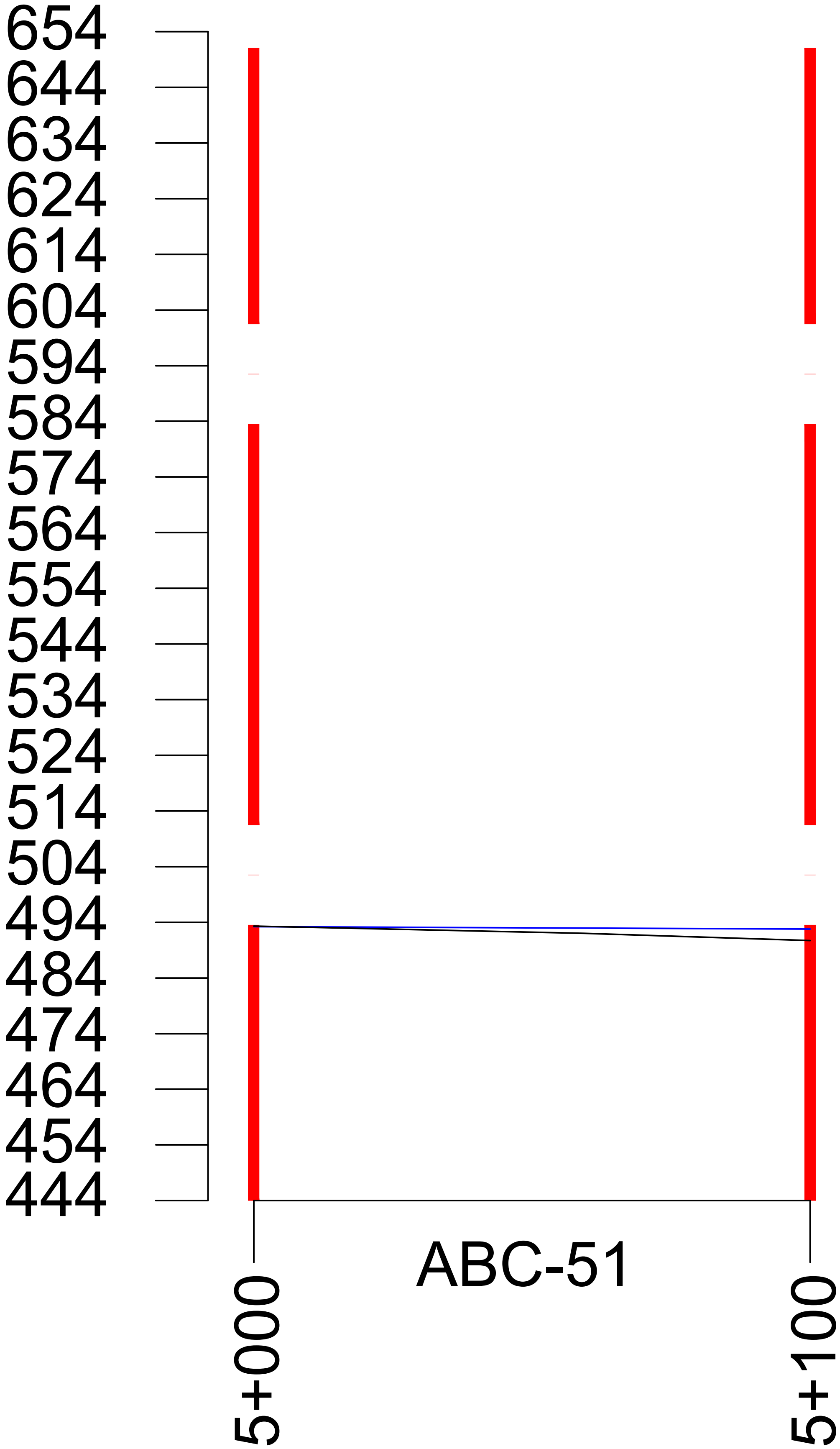

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-47
4+600
4+700

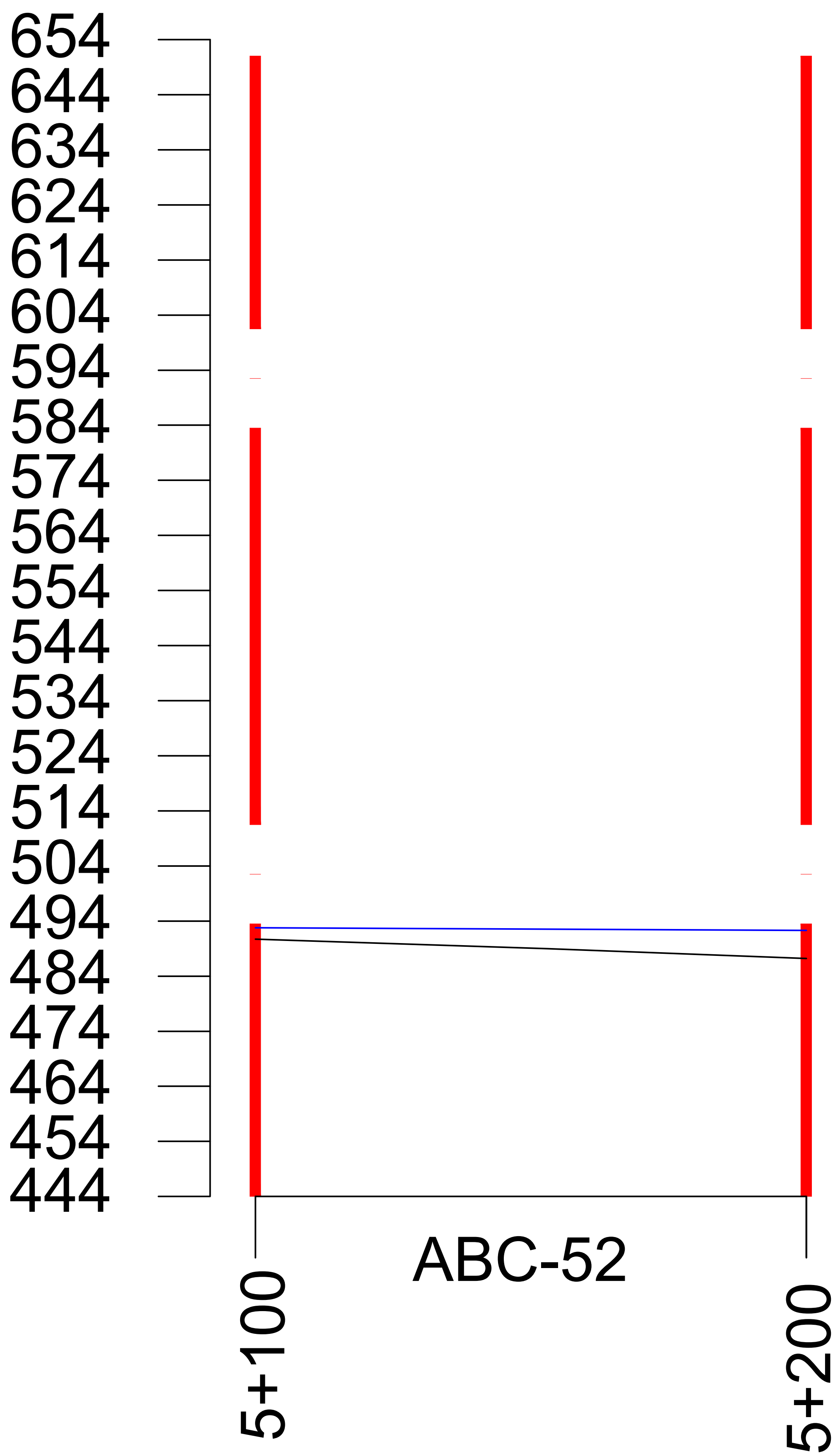

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-48
4+700
4+800



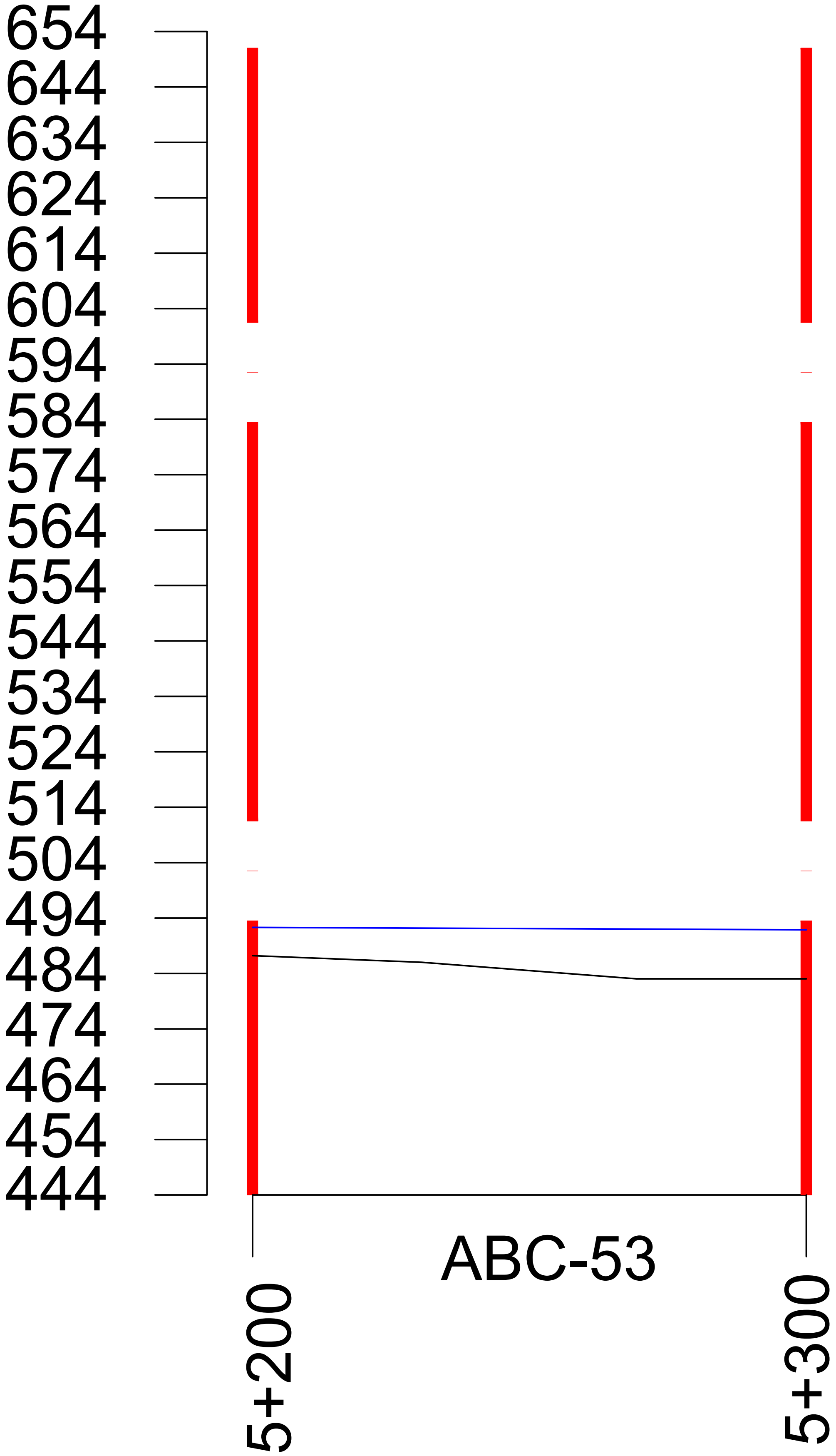
654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-49
4+800
4+900


654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-50
4+900
5+000

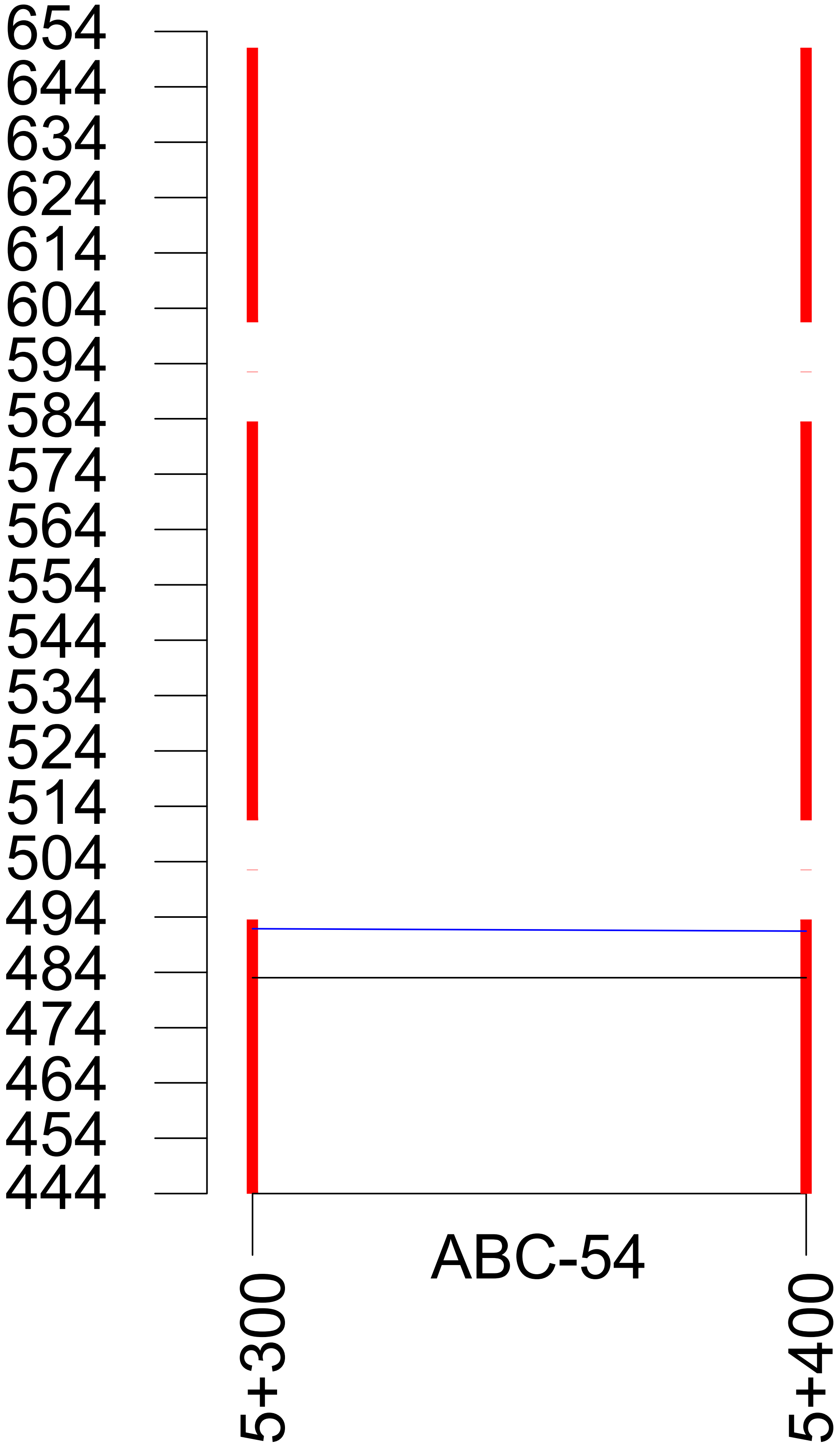

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-51
5+000
5+100

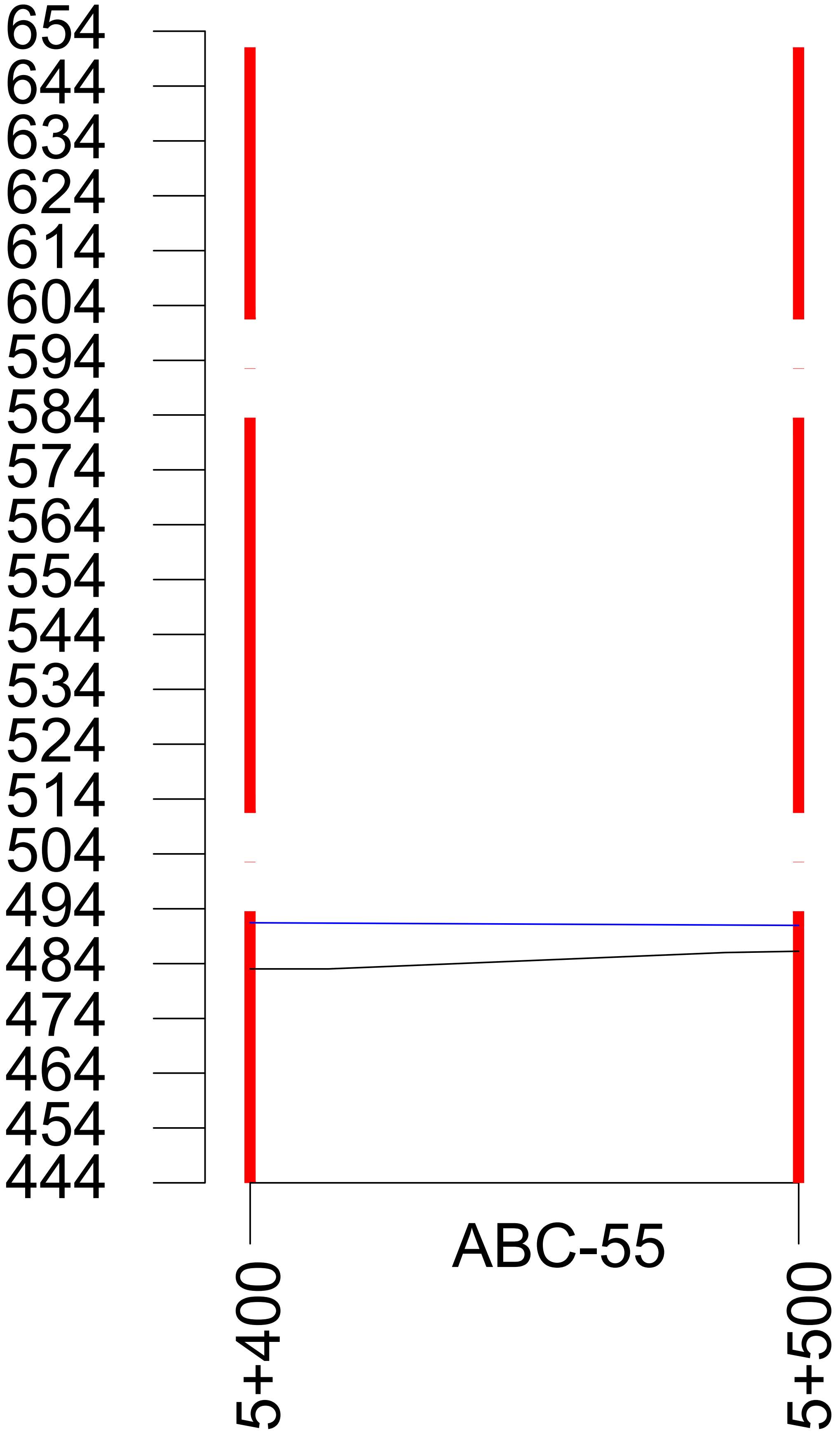


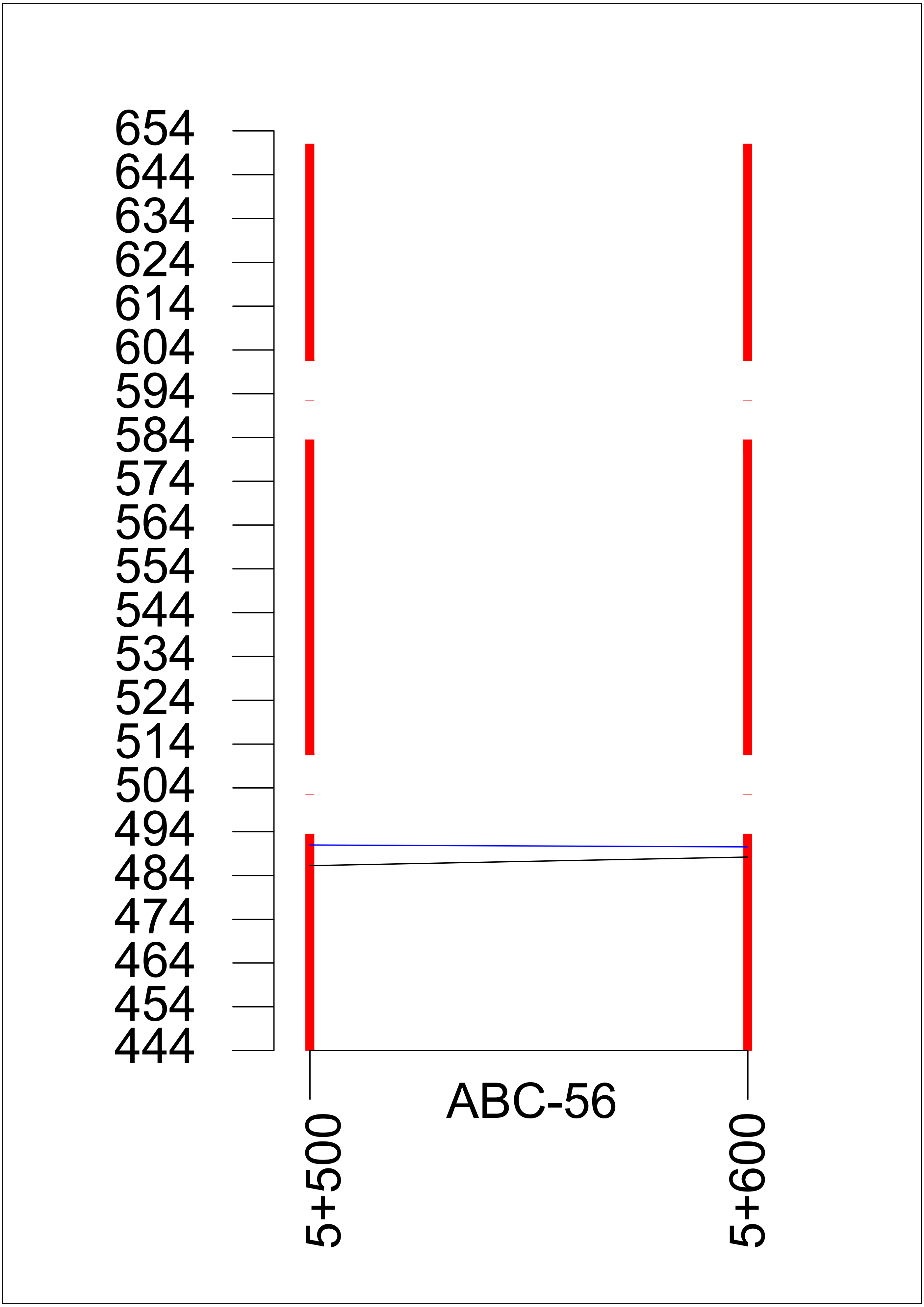
654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-52
5+100
5+200

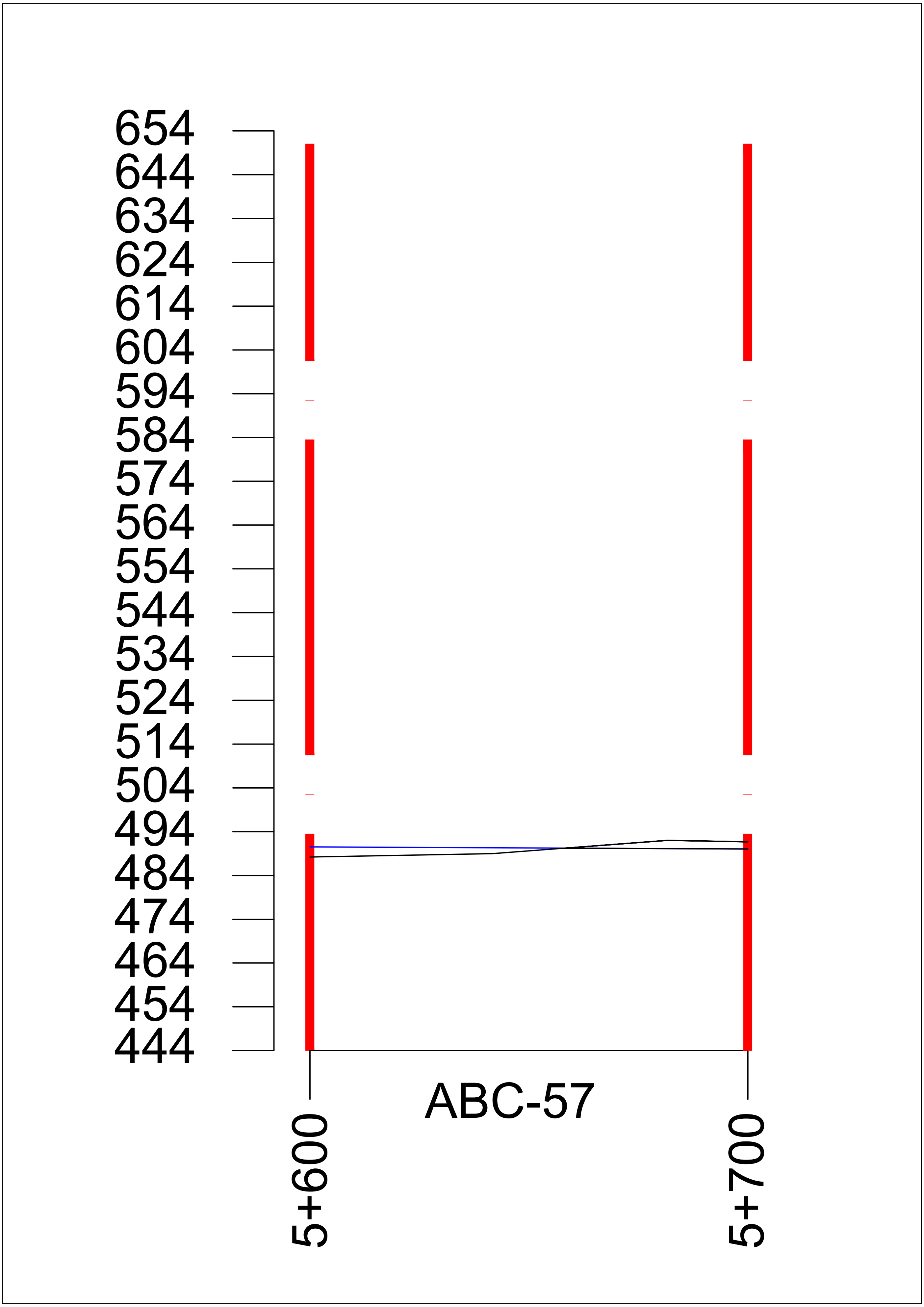


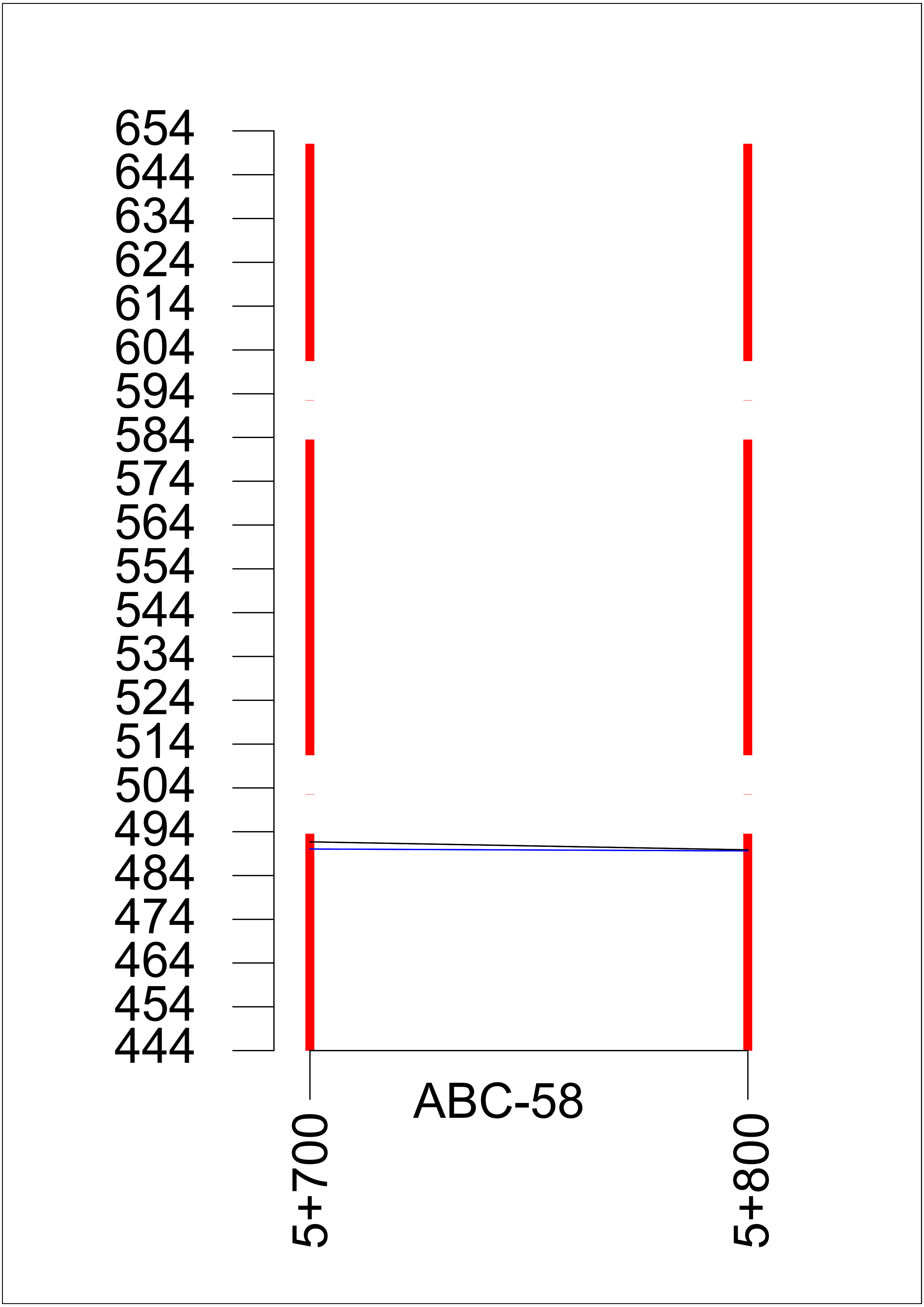
654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-53
5+200
5+300

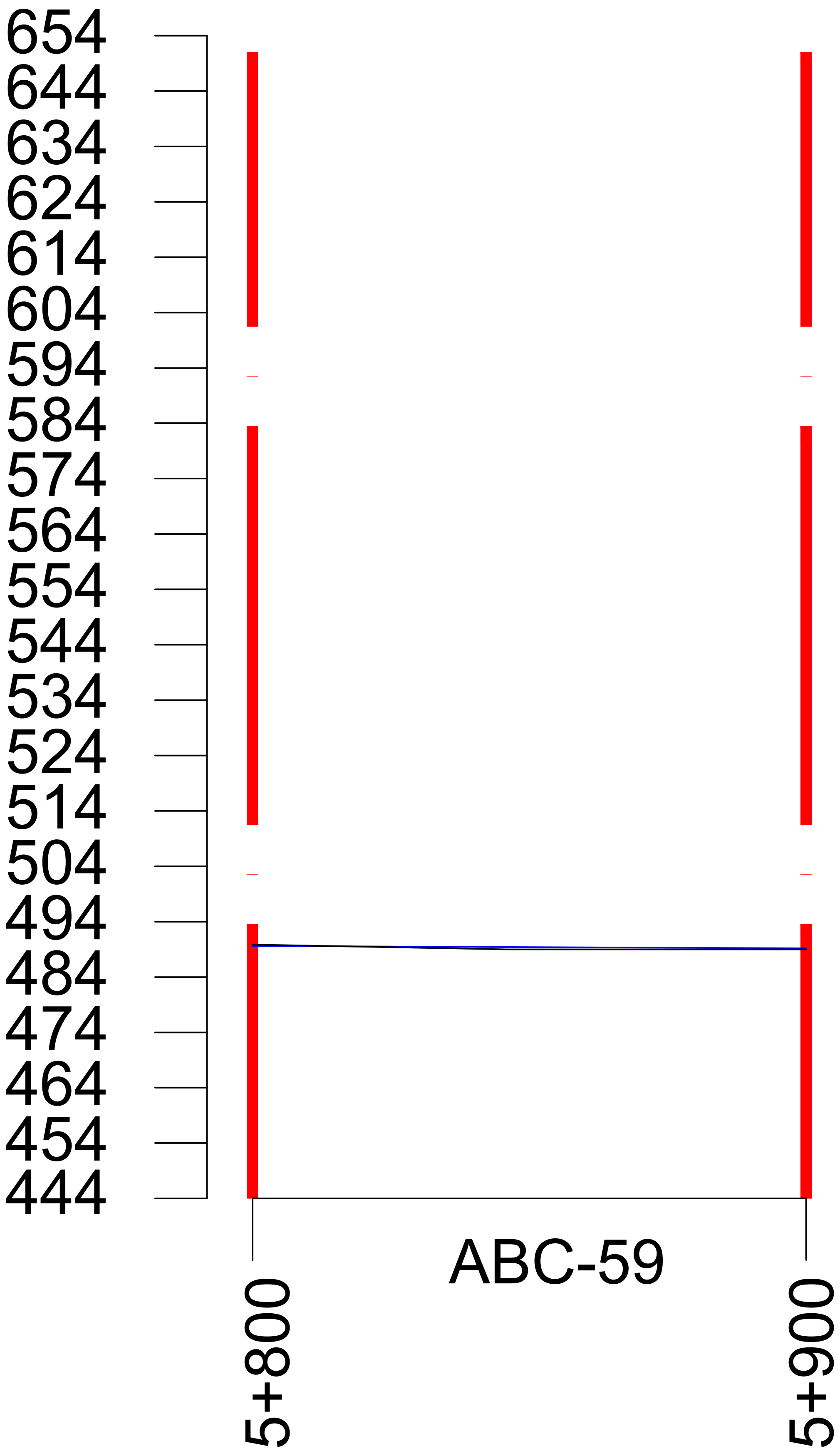

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-54
5+300
5+400

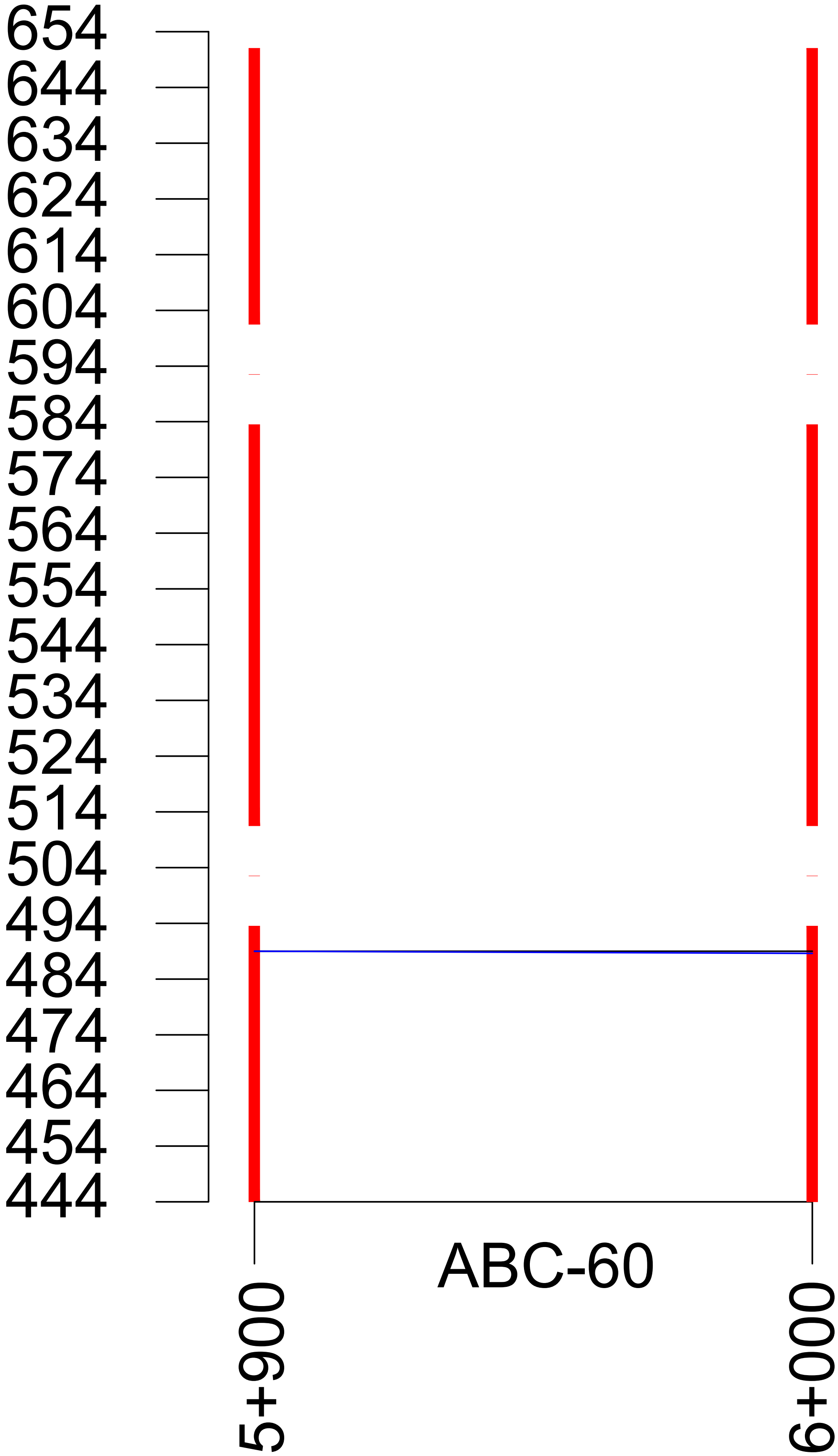

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-55
5+400
5+500

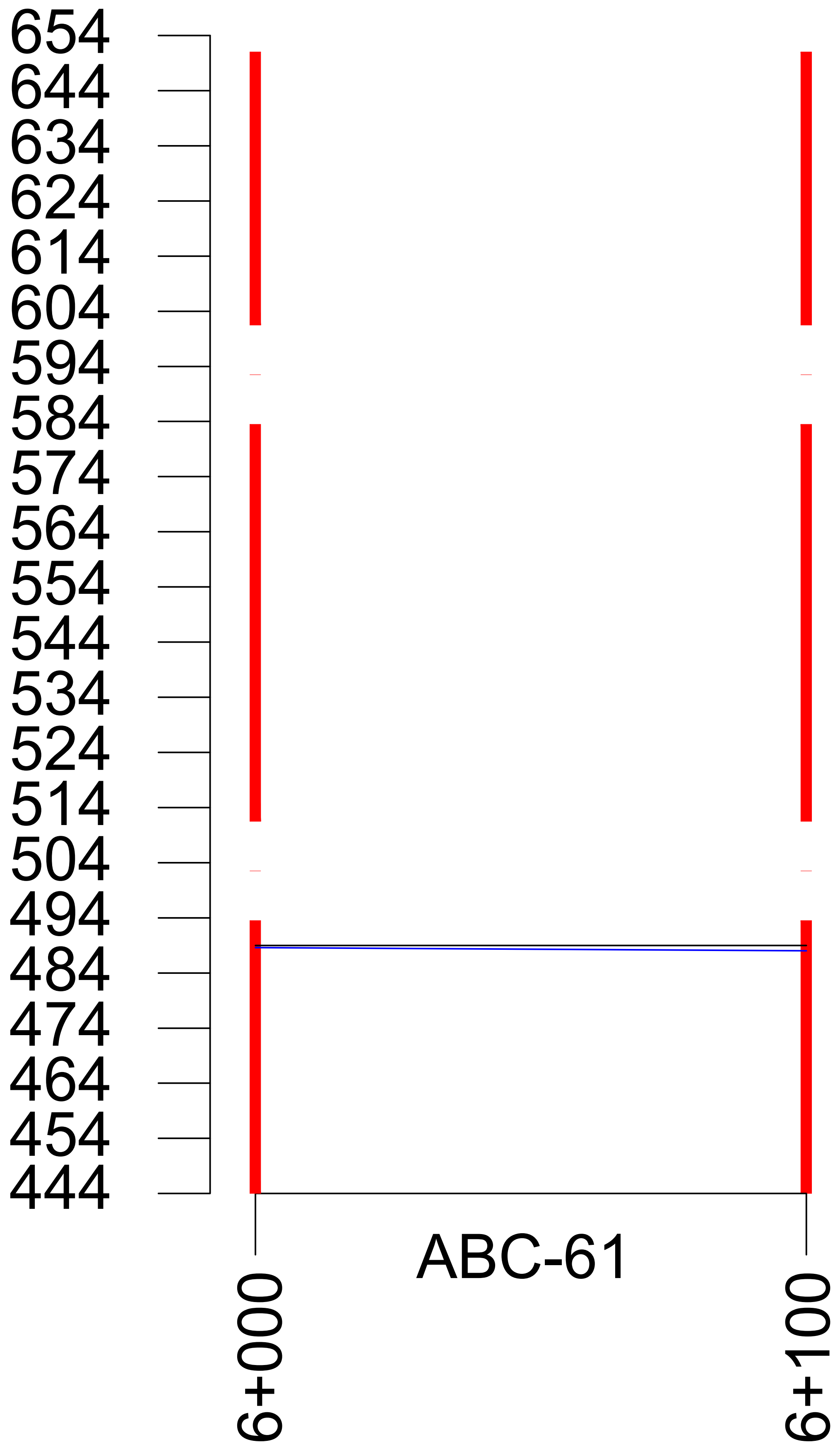

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-56
5+500
5+600

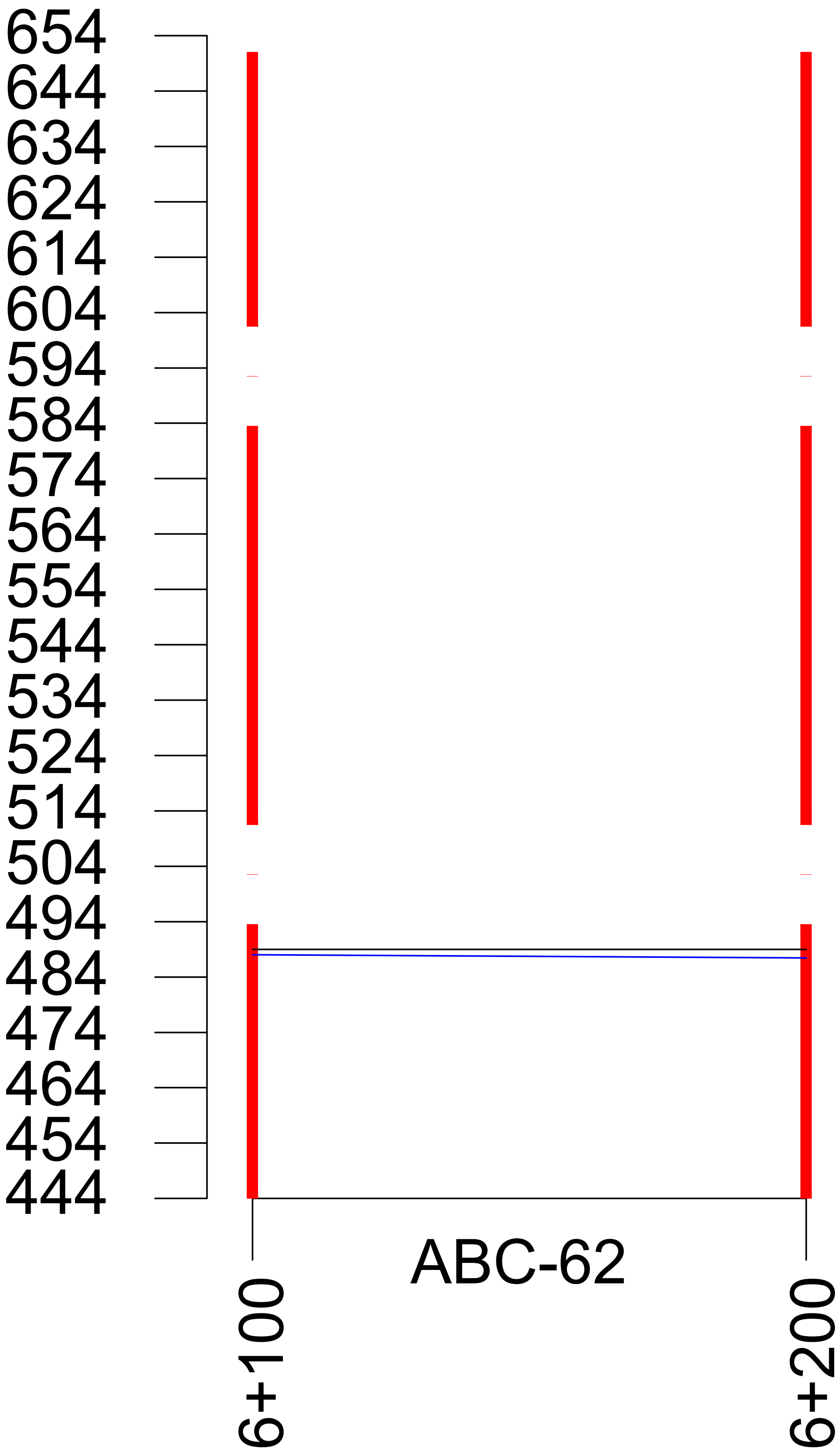

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-57
5+600
5+700

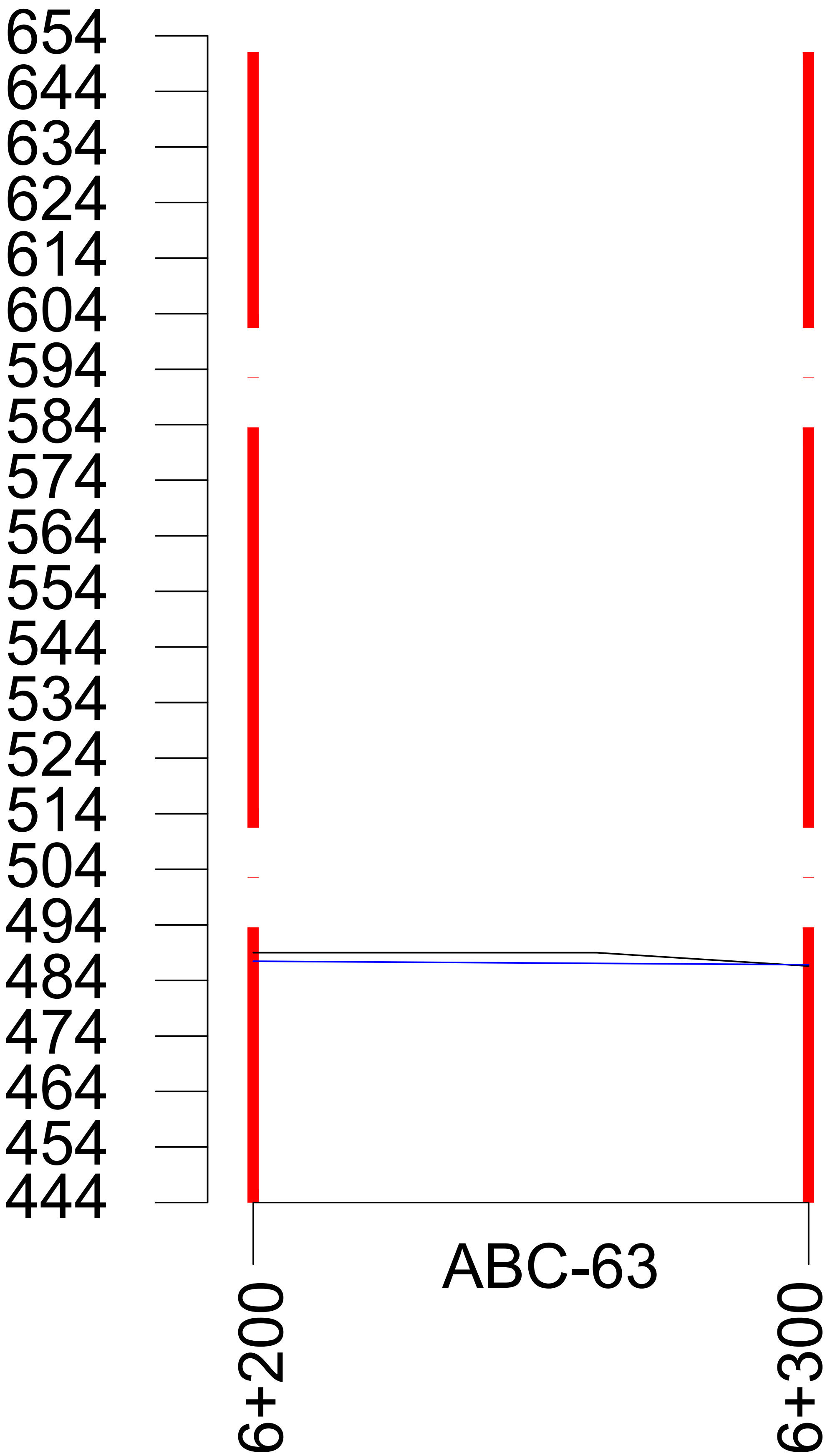

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-58
5+700
5+800

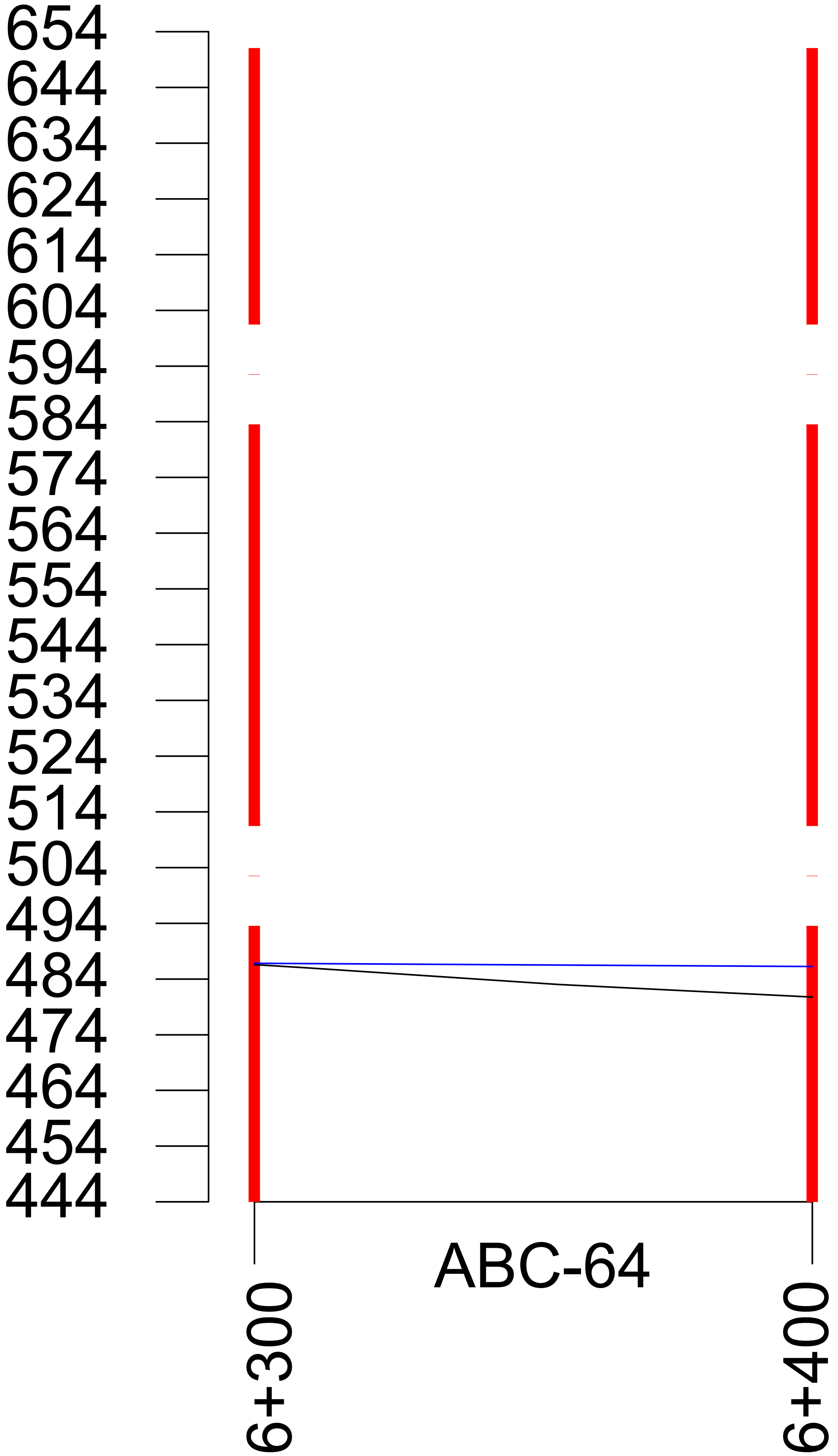

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-59
5+800
5+900

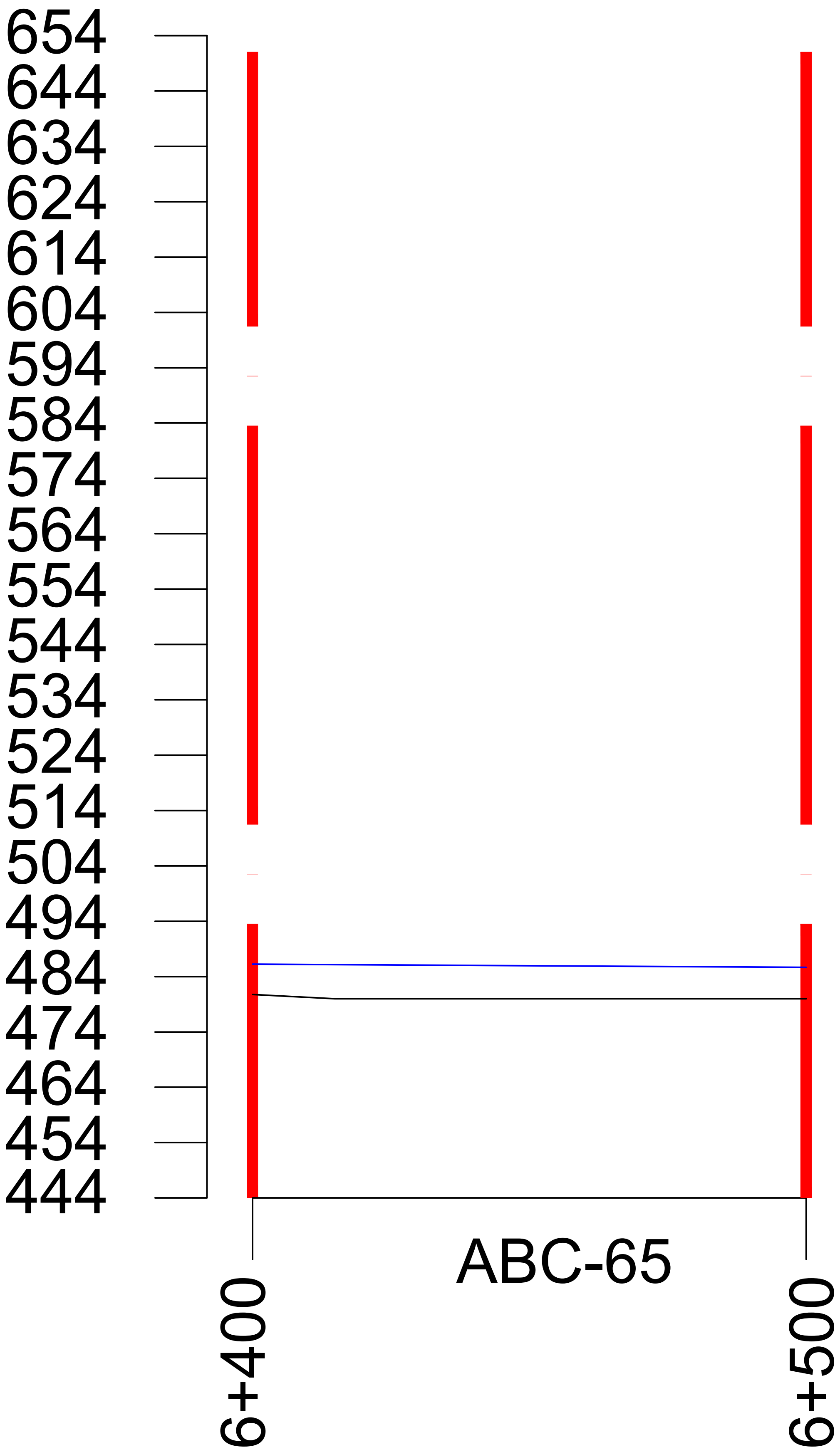

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-60
5+900
6+000


654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-61
6+000
6+100

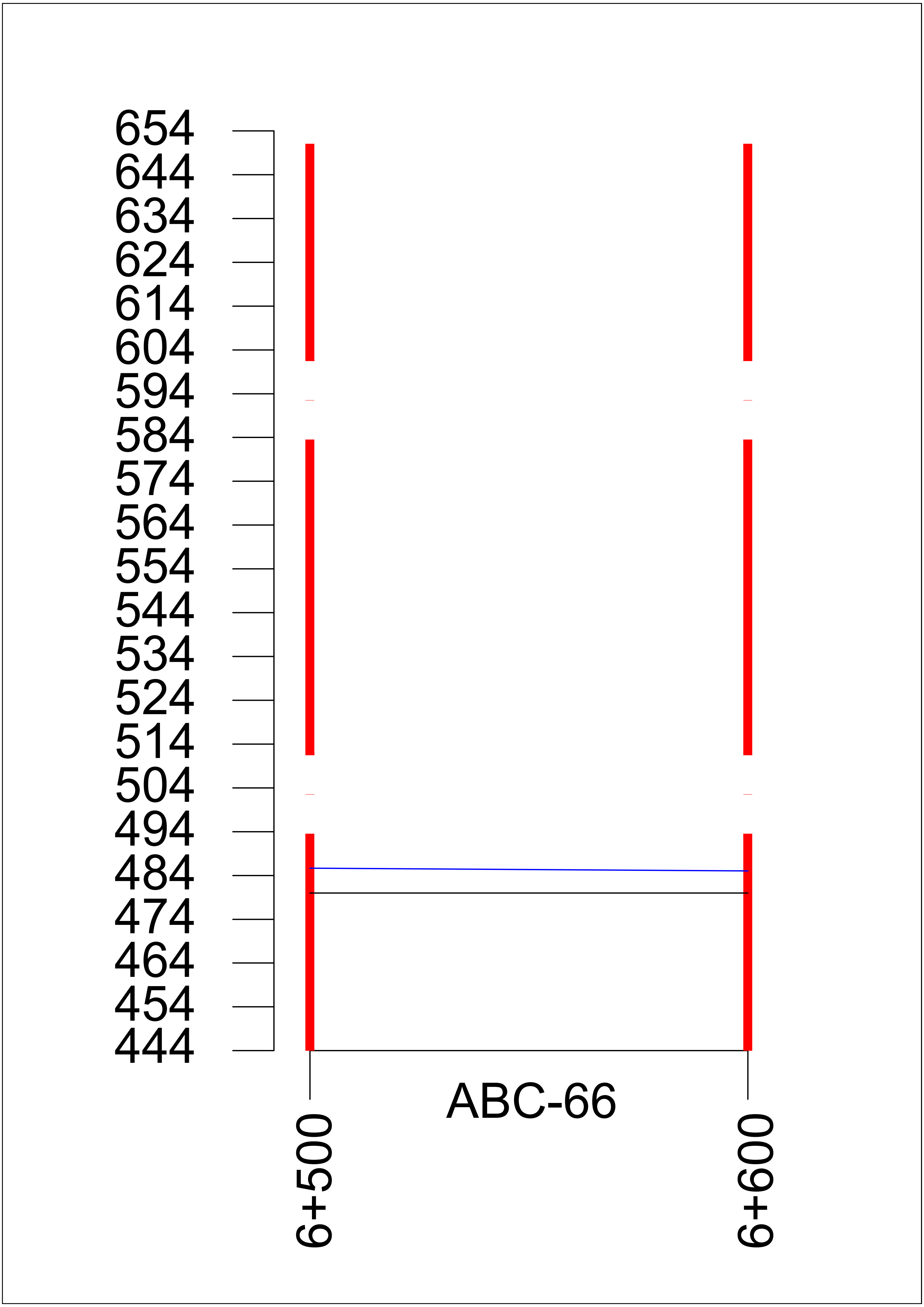

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-62
6+100
6+200

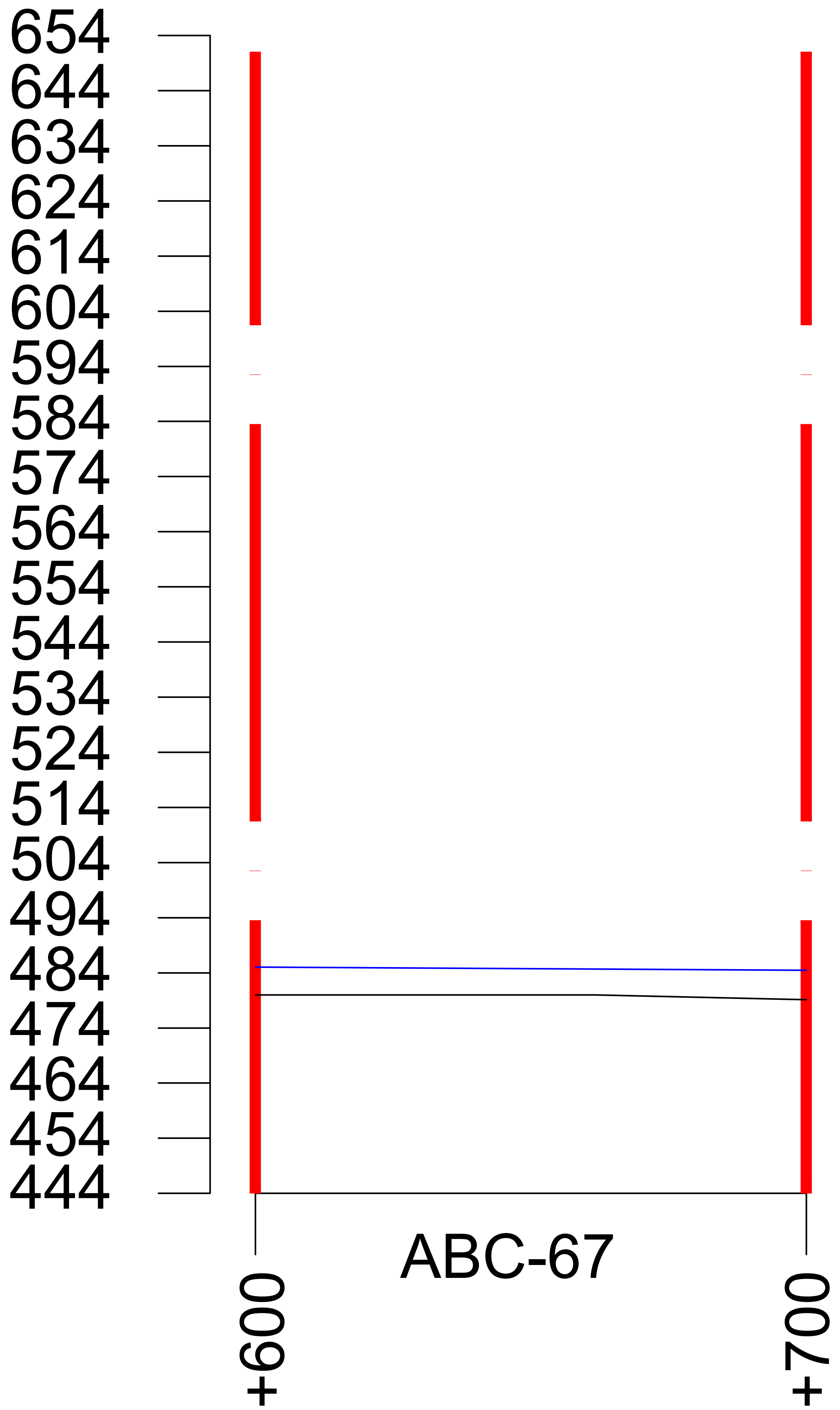

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-63
6+200
6+300

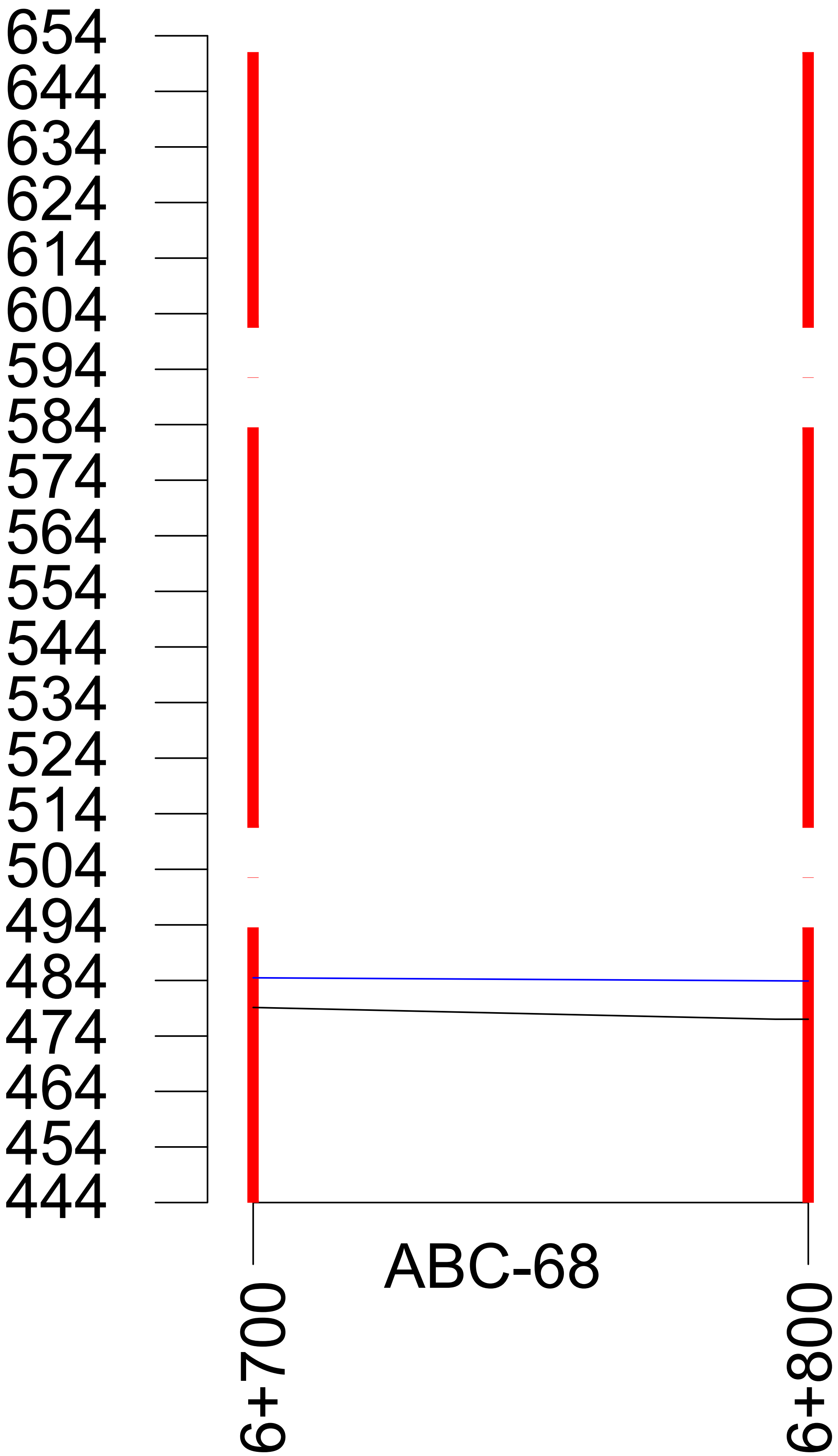

654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-64
6+300
6+400

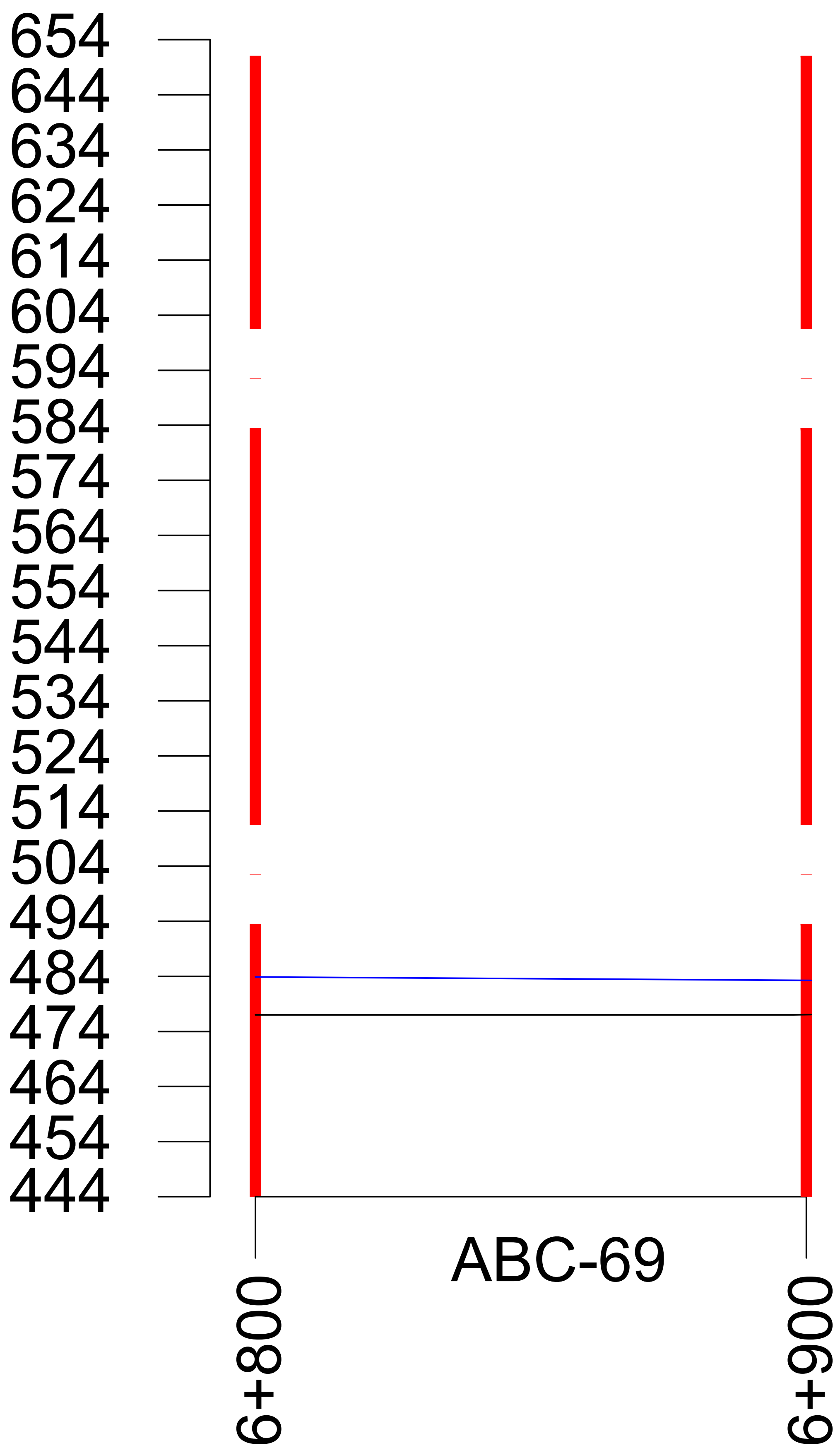


654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-65
6+400
6+500


654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-66
6+500
6+600


654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-67
6+600
6+700


654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-68
6+700
6+800


654
644
634
624
614
604
594
584
574
564
554
544
534
524
514
504
494
484
474
464
454
444
ABC-69
6+800
6+900