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UVX

MINING COST ESTIMATE

Assume 150 TPD production

must - excavate 2000 FT³/DAY

(Assume) STOPE rounds of 8x10x6 = 480 FT³

4.2 rounds/DAY

WILL REQUIRE minimum 3 stopes open at once

2 shifts/day -

Production Crew Complement -	Current
1 - MANAGER	
1 - Super	1 - Super
1 - second shift foreman	2 - mechanics
2 - hoistman	1 - TOP LANDER
8 - miners	6 - miners
4 - haulage	2 - skiploaders
2 - skip loaders	2 - hoistman
2 - mechanics / welders	
2 - supply / TOP LANDERS	
23 total	14 total

PAYROLL Costs

		$ Per/month
1 -	MANAGER	3500
1 -	Super	2500
1 -	Foreman	2700
2 -	Hoistman	5000
8 -	MINERS	19,200
4 -	HAULAGE	8800
2 -	Mechanics	5000
2 -	TOPLANDERS	4400

$51,500 ÷ .8 $64,375

payroll taxes

STATE FUND 1,400

Emp. INS. 6,400

$72,175 /month

$24/TON LABOR

550 VENTILATION OPTIONS

OPTION A

260' NEW DRIFT $65,000

4 AIR DOORS COST UNKNOWN

FANS ON HAND -

BULKHEADS REQUIRED IN ALL OPTIONS UNKNOWN -

TIME REQUIRED 6-8 weeks

SOME CONFLICT WITH ONGOING OPERATIONS

OPTION B

ENLARGE 300' of DRIFT (DROP BACK)
TO ACCOMODATE VENT TUBING

COST ESTIMATE:

DRIFT work (1 week payroll)	$10,000
Vent Tubing	$9,000
INSTALLATION	1,000
Supplies	2,000
	$22,000

4 AIR DOORS

Major conflicts with ongoing operations to DROP BACK -
Would SHUTDOWN EVERYTHING FOR AS much as
A week.

OPTION C

RAISE From 950 to 800 STARTING
@ a point near the 901-S / 901 W intersection

install FAN @ 800 blowing down the raise

4 AIR Required on 950 TO Fact Haust

Air to Audrey —

Cost — 150 to 175 Feet of RAISE
@ $100 / FOOT

MAXIMUM $17,500

OPTION D

INSTALL AIR DOORS

use Vent Bag as we do now to
~~[illegible]~~ convey air to intersection or
install rigid air duct with FAN @ intersection
rigid duct to be same size as current vent bag

Velocity in 36" pipe 1000 CFM Flow Volume

36" = 3'

$A = \pi r^2 = \pi (1.5^2) = 7.07 \text{ FT}^2$

$V = \frac{Vol}{A} = \frac{1000}{7.07} = 141.5 \text{ FT/min}$ or 2.4 FT/sec

24 inch pipe

$A = 3.14 \text{ FT}^2$

$1000/3.14 = 5.3 \text{ FT/sec}$

$$\cancel{H_f = \frac{K P L V^2}{A}}$$

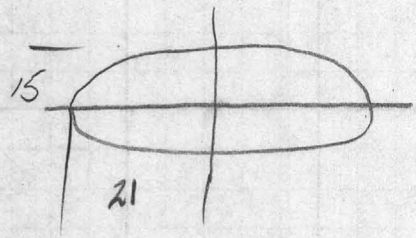
$$H_f = \frac{K P L Q^2}{5.2 A^3} = \frac{15^{-10}(5.4)(300)(1000^2)}{5.2(7.07^3)}$$

$= .0023 \text{ in } H_2O$ 36"

Friction loss in Rigid

$$\frac{15 \times 10^{-10}(6.28)(300)(1000^2)}{5.2(3.14^3)}$$ 24"

$= .02 \text{ in } H_2O$ 24"



$$S = \frac{4\pi}{\sqrt{2}} b\sqrt{a^2+b^2}$$

Feet of drift from PROPOSED FAN INSTALLATION TO Audey SHAFT EXHAUST FAN

2,370 FEET

Assume
$K = 150 \times 10^{-10}$

TABLE 6-1 HARTMAN
Igneous Rock Avg, Slightly obstructed, straight

friction loss in the drifts
Assuming 1000 cfm 6'x7' x-section + K as above

6x7 drift
$$H_f = \frac{(150\times10^{-1})(26)(2370)(1000^2)}{(5.2)(42)^3} = .0024 \text{ in } H_2O$$

7x8 drift
$$H_f = \frac{(150\times10^{-1})(30)(2370)(1000^2)}{(5.2)(56)^3} = .0017 \text{ in } H_2O$$

@ 2000 CFM 6x7 .010 in H_2O

7x8 .005 in H_2O

UVX

Utilities

Phone $300/month

A.P.S.

currently $6,000/month

+50%

Assume - $9,000/month

Note: Metch estimate additional $40,000/year

or $3,330/month

TOTAL $9,300/month

÷ 3000 tons

$3.10/TON

Timber/Rock bolts

@ $280/1000 BOARD FEET

@ $5.00/bolt

estimate 15 board feet/ton (from USBM report UVX)

$4.20/ton

Explosives

round	25 sticks	30.50
	2 boxes	16.75
	25 caps/delays	32.50
		$79.75

≈ 37 tons/round - $79.75/37 TONS = $2.16/ton

Misc Supplies -

JAN to July requirements have ranged from 3 to 11 thousand

Estimate $5,000 $1.67/ton

Assays

2 per round 8 per day

84.00

$0.56/ton

Cost	per ton
LABOR	$24.00
Utilities	3.10
Timber	4.20
Explosives	2.16
Misc Supplies	1.67
Assays	0.56
	$35.69

Timber REQUIREMENTS (CONT.)

TOTAL LENGTH OF 8"x8" REQ.

$\frac{26}{12}\left[(2\times32)+(2\times18)+2(10)+(60)\right]+100 = 490$ FEET

PLUS 10% CONTINGENCY 540 FEET OF 8"x8"

2880 BOARD-FT @ $450 /1000 BD FT (AT mine site)

$1300 FOR TIMBER

LABOR 2 men 1 SHIFT to install = $400

2 men 2 shifts to instal = $800

$1200

RECAP:

Timber $1300

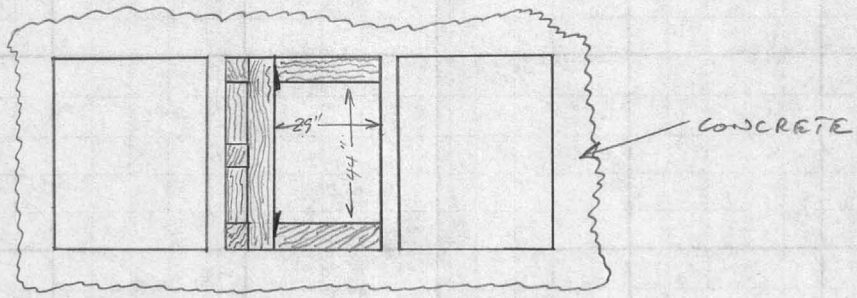
LABOR $1200

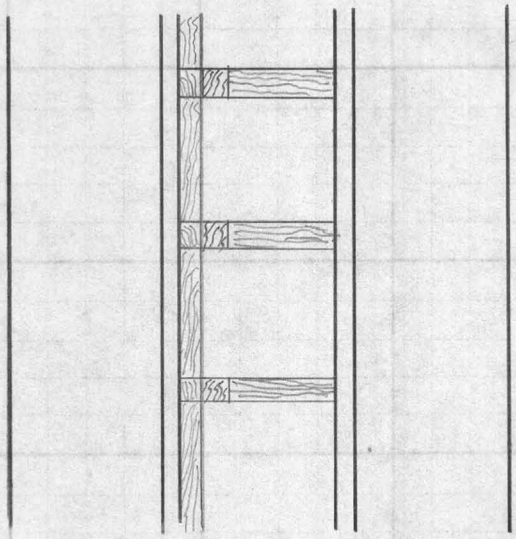
$2500

ESTIMATE OF TIMBER REQUIREMENTS

ROUGH CALCULATIONS INDICATE WALL MUST BE SUPPORTED ALONG CENTER VERTICALLY AND AT NO GREATER THAN 4' CENTERS SET TO SET.

SKETCH OF HELPER SETS -





EACH SET CONSISTS OF: (EXCLUDES 100'x8"x8")

2- 8"x8"x 32"

1- 8"x8"x 60"

2- 8"x8"x 18"

2- 8"x8"x 10" corner blocks

on 4" centers to support 100' fshft 26 sets REQ.

From Peele pg 12-132 to 12-133

$$V = \frac{wR}{k\mu'}\left(1 - e^{-\frac{k\mu' h}{R}}\right)$$

$$L = \frac{wR}{\mu}\left(1 - e^{-\frac{k\mu' h}{R}}\right)$$

where

V = vertical pressure of filling, psf

L = LATERAL pressure of filling, psf

R = Area of bin in sq ft ÷ circumference of bin in ft.

w = wt per cu ft of contents

μ = $\tan\phi$ coef of friction filling on filling

μ' = $\tan\phi'$ coef of friction filling on bin walls

h = height in feet of filling

K = $(1-\sin\phi) \div (1+\sin\phi)$

Values selected for Muck Stuff —

Table 40 Peele page 12-133

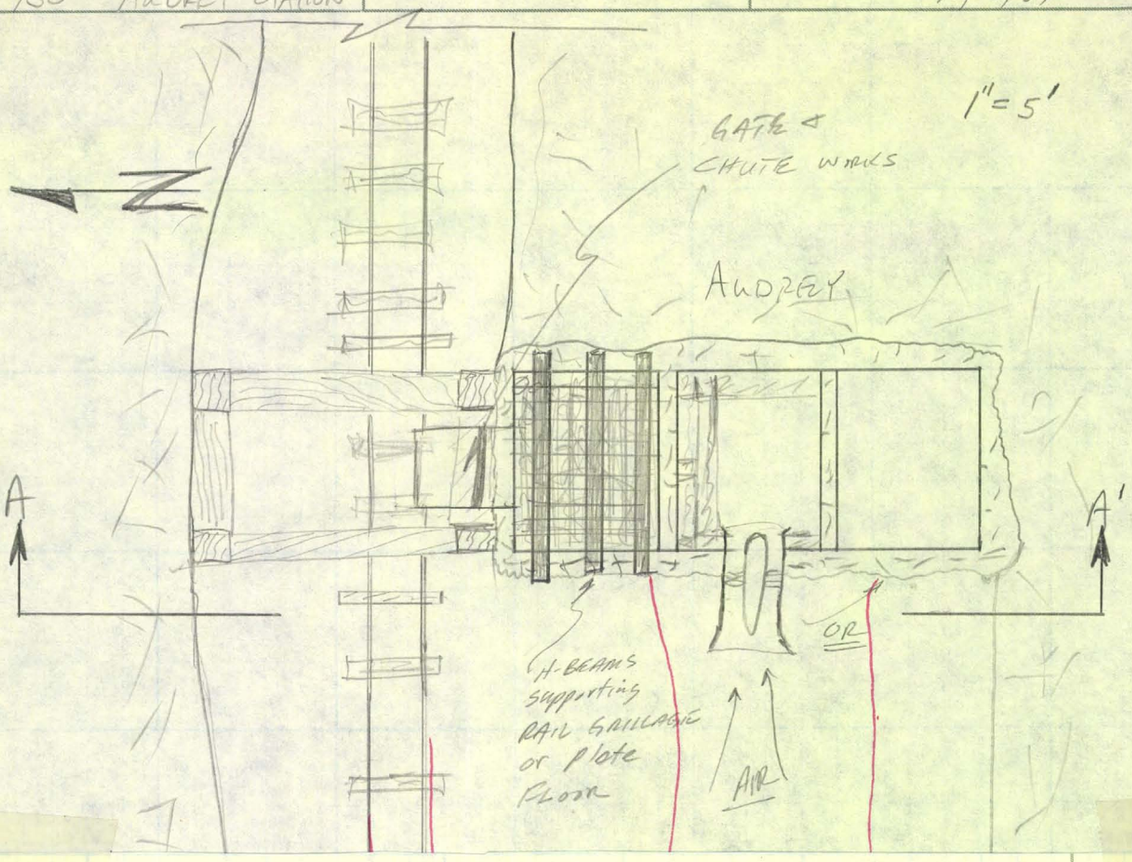
w = 140 lb/cu ft

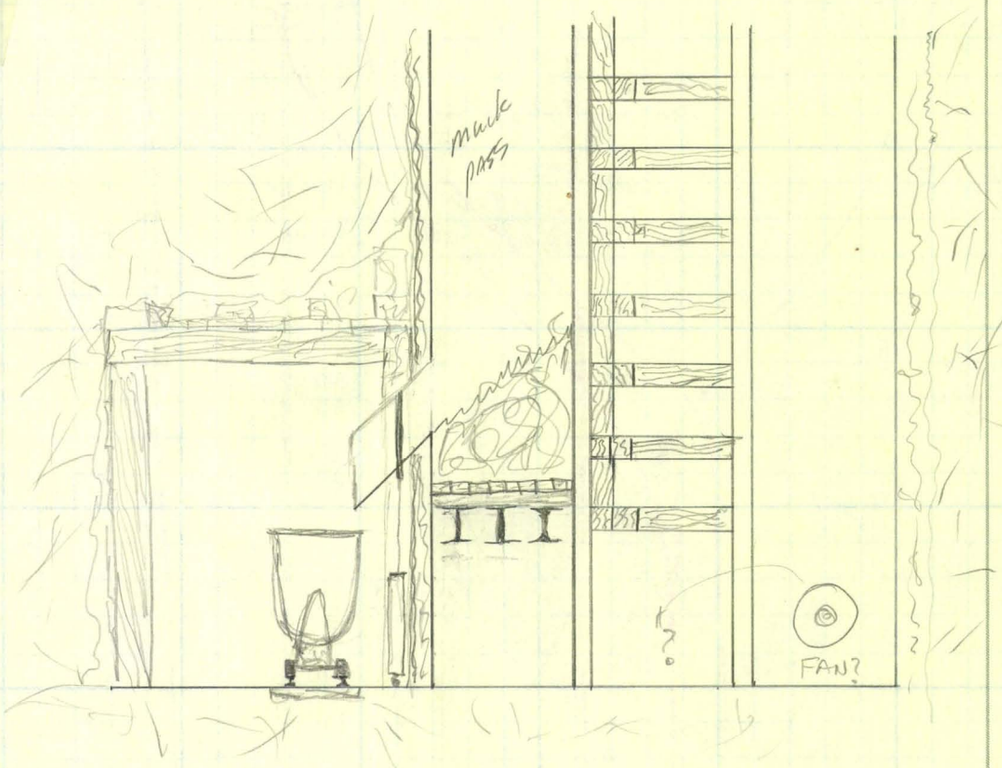
$\phi = 45°$ $\therefore \mu = 1$ $\therefore K = 0.1716$

$\phi' = 40°$ $\therefore \mu' = .8391$

$R = \frac{4 \times 5}{2(4+5)} = 1.1111$

950 AUDREY STATION 10/15/87 1/





$$V = \frac{(140)(1.1111)}{(0.1716)(.8391)}\left(1 - e^{-\frac{(0.1716)(.8391)(150)}{1.1111}}\right)$$

$$V = 1080.22\left(1 - e^{-19.44}\right) \rightarrow 1$$

$$\underline{\underline{V = 1080 \text{ psf}}}$$

$$L = \frac{(140)(1.1111)}{1}\left(1 - e^{-19.44}\right) \rightarrow 1$$

$$\underline{\underline{L = 155.6 \text{ PSF}}} \quad @ \ 150'$$

By STALEY page 189-191

$$N_1 = \frac{1}{2} w h^2 \left(\frac{1 - \sin\phi}{1 + \sin\phi}\right)$$

N_1 = normal force on bin wall acting at 2/3h from top of bin

w = density lb/cu ft

h = height

ϕ = angle of repose

$$\therefore \quad N_1 = \frac{1}{2}\, 140\, (150)^2 \left(\frac{1 - \sin 45^\circ}{1 + \sin 45^\circ}\right)$$

$$= 270,227 \text{ lbs}$$

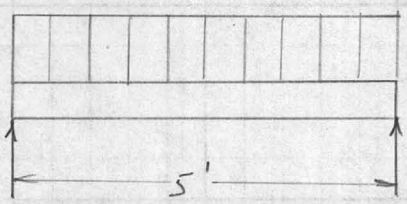
pressure at bottom by $P = \frac{2N_1}{h}$

$P = 3603$ psf

CURTAIN WALL STRENGTH

ISOLATE

5'X1'X6" section for study & treat as beam uniformly loaded and supported only at short edges as shown:



$$S = \frac{bd^2}{6} = \frac{1(.5^2)}{6} = .042 \ FT^2$$

$$A = 1 \times .5 = .5 \ FT^2$$

$$M = \frac{WL}{8} \quad ; \quad V = \frac{W}{2}$$

$$M = F_b S$$

Concrete by Peele 43-11

Tensile 100 to 175 psi use 150 psi or 21,600 psf

Shear 0.5 X compressive

Assume 2000 psi compressive strength

$$M = (21{,}600)(.042)$$

$$M = 907$$ FAILURE BENDING STRESS

$$907 = \frac{W\,5}{8}$$

$W = 1451$ pounds or <u>290 psf</u>

FAILURE SHEAR = 2000 psi X .5 = 1000 psi

or 144,000 psf

$72{,}000 = \frac{w}{2}$

$w = 144{,}000$ pounds

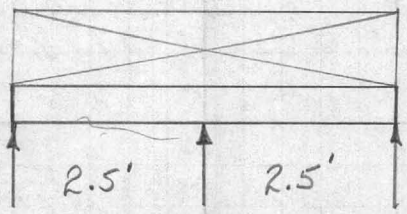
28,800 psf

NOT A FACTOR ??

∴ CANNOT EXCEED 290 psf LOAD against WALL

SHOULD WE SUPPORT IN THE MIDDLE

As below



STILL $M = F_b S = 907$

$M = \frac{(w)2.5}{8} = 2902$ lbs or 1161 psf

SPACING FOR supports

$S = \frac{2.5(.5)^2}{6} = 0.1042 \ FT^2$

$A = 2.5 \times .5 = 1.25 \ FT^2$

$M = (21{,}600)(0.1042) = 2250$ FAILURE

$2250 = \frac{(300)(L^2)}{8}$

$L^2 = \frac{2250(8)}{1161} = 3.9'$ or 4'.75 APART

SHAFT MUCK PASS 10/10/07

The Feasibility of using the Audey SHAFT AS A TRANSFER RAISE FROM THE 800 to 950 Level centers on the question of strength of the DIVIDER WALLS OF THE SHAFT. Un-supported, it is calculated to FAIL AT A LOAD OF 290 psf. Supported along the center, vertically the failure load is estimated to be 1160 psf.

According to calculations BASED ON EXAMPLES in Peele, we can expect HORIZONTAL LOADS of 150-200 psf. This assumes dry material - Using Staley's method, loads of 2000-3500 psf can be achieved. Staley treats the material more like A FLUID THAN PEELE. Since there is water in the shaft at these levels continuously, it must be assumed that our material will be saturated. (Howard King estimates 2000 psf.)

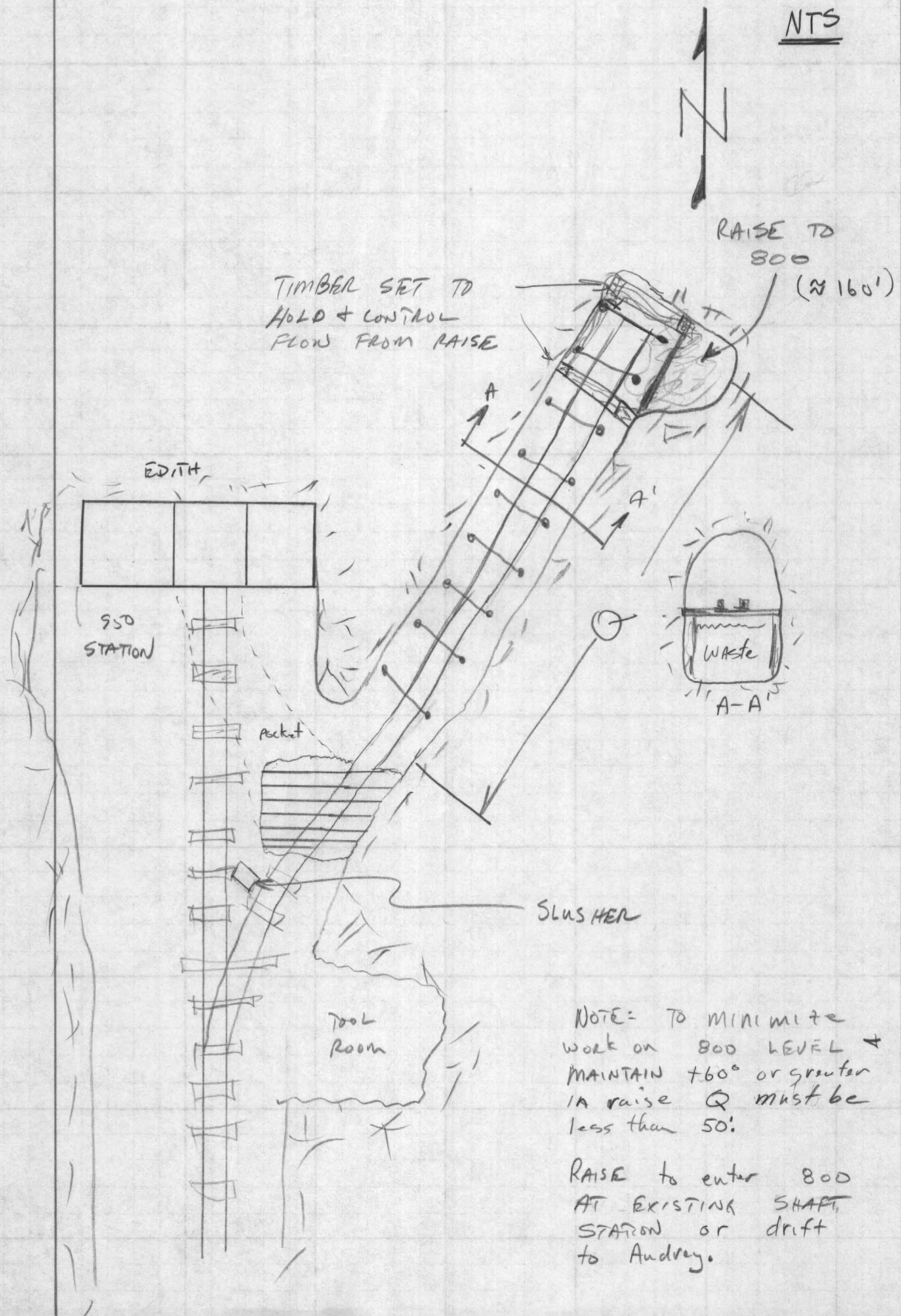
Conclusions: ① SHAFT DIVIDER WALL must be supported for at least bottom 2/3 of height. ② EVEN with support, shock LOADS MAY damage concrete. ③ Uncertain WHAT LATERAL LOADS to design for. ④ Tensile strength of concrete & amount of steel reinforcement unknown.

SHAFT Muck PASS

The LAST BLAST ROUND TO ENTER Audrey SHAFT at 550 LEVEL, REMOVED as much as 5 VERTICAL FEET OF both DIVIDER WALLS. THERE WERE WINDOWS IN THE DIVIDER WALLS AT THE 550 LEVEL. I'm SURE THE PRESENCE OF THESE WINDOWS CONTRIBUTED TO THE DAMAGE DONE.

The loss OF THESE WALLS MAKES THE USE OF NORTH compartment for a transfer raise much more difficult.

The alternative to consider is to complete the planned tail drift for the dump pocket at the Edith AND then RAISE from it to an appropriate point on the 800 Level.



NOTE: TO MINIMIZE work on 800 LEVEL & MAINTAIN +60° or greater IN raise Q must be less than 50'.

RAISE to enter 800 AT EXISTING SHAFT STATION or drift to Audrey.

Polaris Observation

NOTES: 11/3/87 Temp 50° F ELEVATION ≈ 4900

Longitude ≈ 112° 7'00"
LATITUDE ≈ 34° 45'
} USGS 7.5 minute Series Cottonwood Quad.

BS	IS	ANGLE RT.	VA	Time	FS
S1	S2	88°43'35"	57°36'42" ~~54°46'32"~~	7:15:30	Polaris
		177°36'54"	302°17'36"	7:27:30	

Avg. ∡ RT. = 88° 48' 27"

Avg. VA = 32° 20' 27" + (1'32" .95) = 01' 18"

AVG VA corrected 32° 21' 59"

LOCAL HOUR ANGLE

LHA CALCULATION

WATCH TIME 3 NOV 87 (MST)	7 h	21 m	30 s
Change to 24 hr basis (MST)	15 h	21 m	30 s
Correction for time zone	+ 7 h	00 m	00 s
GMT 4 NOV 87	2 h	21 m	30 s
Correction to LMT	- 7 h	31 m	14 s
LMT	18 h	50 m	16 s

NATIONAL 42-383 Made in U.S.A.

Don White
Aug. 1986

U.V.X.

Level		Elev*	Δ	Floors	Ft/floor	Remarks
Daisy shaft collar		5048				
			140			
Edith shaft collar		4908				
			121			
Bitter Cr. tunnel portal		4787				
			37			
Columbia shaft collar		4750				
			25			
300		4725				
			152			
550		4573				
			72			
600		4501				
			87	11	7.9	
700	Also called 9th floor of 600 level	4414				
			80	8	10.0	
800		4333				
			79	10	7.9	
903 Int. (8th floor above 950)		4254				
			77	7	11.0	
950		4177				
			157	19	8.3	
1100		4020				
			113	14	8.1	
1200		3907				
			100	12	8.3	
1300		3807				
			99			
1400		3708				
			100			
1500		3608				
			100			
1600		3508				

UVX Elevations
info for Joe

* Elevation reported for sill floor at Edith shaft station for levels from the 1300 [illegible] Audrey shaft station for 1400 - 1600 levels

U.V. / U.V.X. Coordinate Conversion

From P. Lindberg
Dept 583

0+00(U.V.) = 11,085 N. (U.V.X)

0+00(U.V.) = 4,395 E (U.V.X)

to convert United Verde Coordinates to United Verde Extension Coord.

Northing

Add + 11,085' (North of 0+00 UV)

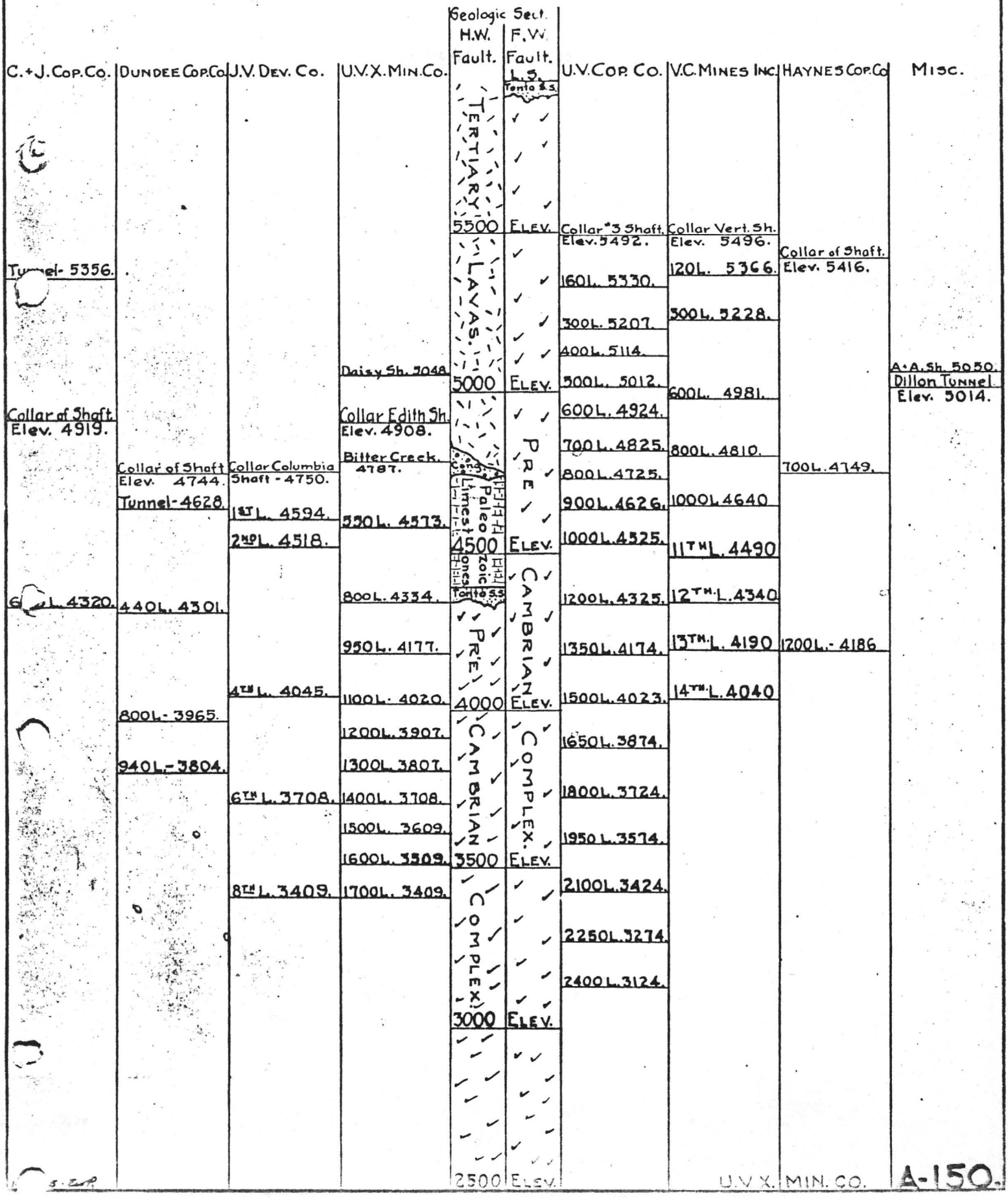
11,085 − UV coord. (South of 0+00 UV)

Easting:

Add + 4,395' (East of 0+00 UV)

4,395 − U.V. Coord West of 0+00 (U.V.)

ELEVATIONS OF MINE WORKINGS
JEROME DISTRICT.



United Verde Extension

Various Mine Elevations

Collar Dairy Shaft		5048	
Collar Edith Shaft — 300-Level	4725	4908.43	
550 sill Edith Shaft {600-Level	4501	4573.17	
800 " " " {700-Level	4414	4333.44	
950 " " " — 903-Jr. level		4176.63	
1100 " " "		4020.38	
1200 " " "		3907.64	
1300 " " "		3807.40	
1400 sill Audrey Shaft		3708.06	
1500 " " "		3608.17	
1600 " " "		3508.22	
1700 " " "		3408.10	
1800 " " "		~3309	
1900 " " "		3209	
Portal Bitter Creek Tunnel		4787	
Collar Columbia Shaft		4749.76	
Jerome Verde Hoisting Station		4700	approximately
" " 157 level		4593	"
" " 232 level		4528	"
" " 426 Station		4324	"
" " 550 "		4200	"
" " 843 "		3907	
" " 943 "		3807	"
" " 1043 "		3706.42	
United Verde Collar No. 3 Shaft	5492	5500	Approximately
" " 500 Tunnel	5012	5000	"
" " 1000 Main Tunnel	4525	4500	"

Date		AT GREENWICH APPARENT NOON: THE SUN'S Apparent Declination	Diff. for 1 Hour	Semi-diameter	Time Semi-diameter Passing Mer.	Equation of Time, Subtract from / Add to Apparent Time	POLARIS FOR THE MERIDIAN OF GREENWICH, CIVIL DATE AND MEAN TIME: Upper Culmination	Elongation Lat. 40°	Declination
NOVEMBER, 1987									
		° ′ ″	″	′ ″	s	m s	h m	h m	′ ″ (+89°)
Mon.	16	S18 40 12.3	−37.70	16 11.94	69	15 18.69	10 38.2 P.M.	W.E. 4 38.5 A.M.	12 47.52
Tues.	17	18 55 07.3	36.87	16 12.14	69	15 07.54	10 34.2	4 34.6	12 47.85
Wed.	18	19 09 42.2	36.02	16 12.35	69	14 55.54	10 30.3	4 30.6	12 48.17
Thur.	19	19 23 56.4	35.16	16 12.55	69	14 42.70	10 26.4	4 26.7	12 48.50
Fri.	20	19 37 49.8	34.28	16 12.75	69	14 29.02	10 22.4	4 22.8	12 48.84
Sat.	21	19 51 21.7	33.38	16 12.95	69	14 14.52	10 18.5	4 18.8	12 49.20
Sun.	22	20 04 32.0	32.47	16 13.15	69	13 59.21	10 14.6	4 14.9	12 49.58
Mon.	23	20 17 20.1	31.54	16 13.34	69	13 43.11	10 10.6	4 11.0	12 49.99
Tues.	24	20 29 45.8	30.59	16 13.54	69	13 26.24	10 06.7	4 07.0	12 50.40
Wed.	25	20 41 48.7	29.64	16 13.73	70	13 08.61	10 02.8	4 03.1	12 50.80
Thur.	26	20 53 28.4	28.66	16 13.91	70	12 50.24	9 58.8	3 59.1	12 51.19
Fri.	27	21 04 44.5	27.68	16 14.10	70	12 31.15	9 54.9	3 55.2	12 51.56
Sat.	28	21 15 36.8	26.68	16 14.28	70	12 11.36	9 50.9	3 51.3	12 51.89
Sun.	29	21 26 05.0	25.66	16 14.45	70	11 50.87	9 47.0	3 47.3	12 52.21
Mon.	30	S21 36 08.7	−24.64	16 14.62	70	11 29.72	9 43.0 P.M.	W.E. 3 43.4 A.M.	12 52.50
DECEMBER, 1987									
Tues.	1	S21 45 47.6	−23.60	16 14.79	70	11 07.90	9 39.1 P.M.	W.E. 3 39.4 A.M.	12 52.79
Wed.	2	21 55 01.6	22.56	16 14.95	70	10 45.45	9 35.2	3 35.5	12 53.08
Thur.	3	22 03 50.3	21.50	16 15.11	70	10 22.38	9 31.2	3 31.5	12 53.39
Fri.	4	22 12 13.6	20.43	16 15.26	70	9 58.71	9 27.3	3 27.6	12 53.71
Sat.	5	22 20 11.1	19.36	16 15.40	70	9 34.47	9 23.3	3 23.7	12 54.04
Sun.	6	22 27 42.6	18.27	16 15.54	71	9 09.66	9 19.4	3 19.7	12 54.39
Mon.	7	22 34 48.0	17.17	16 15.68	71	8 44.31	9 15.5	3 15.8	12 54.73
Tues.	8	22 41 26.9	16.07	16 15.80	71	8 18.45	9 11.5	3 11.8	12 55.08
Wed.	9	22 47 39.2	14.95	16 15.93	71	7 52.09	9 07.6	3 07.9	12 55.42
Thur.	10	22 53 24.6	13.83	16 16.05	71	7 25.28	9 03.6	3 04.0	12 55.75
Fri.	11	22 58 43.0	12.70	16 16.16	71	6 58.02	8 59.7	3 00.0	12 56.06
Sat.	12	23 03 34.1	11.56	16 16.26	71	6 30.35	8 55.7	2 56.1	12 56.35
Sun.	13	23 07 57.8	10.41	16 16.37	71	6 02.30	8 51.8	2 52.1	12 56.62
Mon.	14	23 11 53.9	9.26	16 16.46	71	5 33.90	8 47.8	2 48.2	12 56.87
Tues.	15	23 15 22.3	8.10	16 16.56	71	5 05.18	8 43.9	2 44.2	12 57.12
Wed.	16	23 18 22.8	6.94	16 16.65	71	4 36.17	8 39.9	2 40.3	12 57.36
Thur.	17	23 20 55.4	5.77	16 16.73	71	4 06.90	8 36.0	2 36.3	12 57.61
Fri.	18	23 22 59.8	4.60	16 16.81	71	3 37.42	8 32.0	2 32.4	12 57.87
Sat.	19	23 24 36.2	3.43	16 16.89	71	3 07.76	8 28.1	2 28.4	12 58.15
Sun.	20	23 25 44.2	2.25	16 16.96	71	2 37.96	8 24.1	2 24.5	12 58.45
Mon.	21	23 26 24.1	− 1.07	16 17.03	71	2 08.05	8 20.2	2 20.5	12 58.76
Tues.	22	23 26 35.6	+ 0.11	16 17.10	71	1 38.08	8 16.2	2 16.6	12 59.08
Wed.	23	23 26 18.8	1.29	16 17.17	71	1 08.10	8 12.3	2 12.6	12 59.38
Thur.	24	23 25 33.7	2.47	16 17.23	71	0 38.13	8 08.3	2 08.7	12 59.65
Fri.	25	23 24 20.3	3.65	16 17.28	71	0 08.23	8 04.4	2 04.7	12 59.89
Sat.	26	23 22 38.7	4.82	16 17.33	71	0 21.59	8 00.4	2 00.8	13 00.10
Sun.	27	23 20 28.8	6.00	16 17.38	71	0 51.28	7 56.5	1 56.8	13 00.29
Mon.	28	23 17 50.7	7.17	16 17.42	71	1 20.80	7 52.5	1 52.9	13 00.47
Tues.	29	23 14 44.6	8.34	16 17.46	71	1 50.13	7 48.6	1 48.9	13 00.64
Wed.	30	23 11 10.6	9.50	16 17.49	71	2 19.24	7 44.6	1 45.0	13 00.82
Thur.	31	23 07 08.7	10.65	16 17.51	71	2 48.09	7 40.7	1 41.0	13 01.01
Fri.	32	S23 02 39.1	+11.81	16 17.53	71	3 16.66	7 36.7 P.M.	W.E. 1 37.1 A.M.	13 01.22

The sign + prefixed to the hourly change of declination indicates that {north / south} declinations are {increasing. / decreasing.}

The sign − prefixed to the hourly change of declination indicates that {south / north} declinations are {increasing. / decreasing.}

AT GREENWICH APPARENT NOON							POLARIS FOR THE MERIDIAN OF GREENWICH, CIVIL DATE AND MEAN TIME		
Date	THE SUN'S Apparent Declination	THE SUN'S Diff. for 1 Hour	THE SUN'S Semi-diameter	Time Semi-diameter Passing Mer.	Equation of Time, Subtract from Apparent Time		Upper Culmination	Elongation Lat. 40°	Declination
OCTOBER, 1987									
	° ′ ″	″	′ ″	s	m s		h m	h m	+89° ′ ″
Thur. 1	S 3 05 00.8	−58.20	16 00.05	64	10 10.88		1 42.7 A.M.	E.E. 7 42.4 P.M.	12 30.06
Fri. 2	3 28 16.5	58.10	16 00.33	64	10 30.21		1 38.8	7 38.5	12 30.45
Sat. 3	3 51 29.6	57.99	16 00.61	64	10 49.25		1 34.8	7 34.6	12 30.85
Sun. 4	4 14 40.0	57.87	16 00.89	64	11 07.98		1 30.9	7 30.6	12 31.22
Mon. 5	4 37 47.3	57.73	16 01.17	64	11 26.38		1 27.0	7 26.7	12 31.57
Tues. 6	5 00 51.0	57.58	16 01.45	65	11 44.42		1 23.1	7 22.8	12 31.90
Wed. 7	5 23 51.1	57.42	16 01.73	65	12 02.09		1 19.2	7 18.9	12 32.22
Thur. 8	5 46 47.0	57.24	16 02.00	65	12 19.34		1 15.2	7 14.9	12 32.52
Fri. 9	6 09 38.6	57.05	16 02.28	65	12 36.17		1 11.3	7 11.0	12 32.84
Sat. 10	6 32 25.4	56.84	16 02.55	65	12 52.55		1 07.4	7 07.1	12 33.17
Sun. 11	6 55 07.1	56.63	16 02.82	65	13 08.46		1 03.5	7 03.2	12 33.52
Mon. 12	7 17 43.4	56.39	16 03.09	65	13 23.88		0 59.6	6 59.3	12 33.89
Tues. 13	7 40 13.9	56.14	16 03.36	65	13 38.78		0 55.7	6 55.4	12 34.28
Wed. 14	8 02 38.1	55.87	16 03.63	65	13 53.15		0 51.7	6 51.4	12 34.67
Thur. 15	8 24 55.8	55.59	16 03.90	65	14 06.97		0 47.8	6 47.5	12 35.08
Fri. 16	8 47 06.5	55.29	16 04.17	65	14 20.22		0 43.9	6 43.6	12 35.48
Sat. 17	9 09 09.9	54.98	16 04.44	65	14 32.88		0 40.0	6 39.7	12 35.87
Sun. 18	9 31 05.5	54.65	16 04.71	65	14 44.94		0 36.1	6 35.7	12 36.25
Mon. 19	9 52 52.9	54.30	16 04.98	65	14 56.38		0 32.1	6 31.8	12 36.62
Tues. 20	10 14 31.7	53.93	16 05.25	66	15 07.19		0 28.2	6 27.9	12 36.97
Wed. 21	10 36 01.6	53.55	16 05.51	66	15 17.35		0 24.3	6 24.0	12 37.31
Thur. 22	10 57 22.1	53.15	16 05.78	66	15 26.84		0 20.4	6 20.0	12 37.65
Fri. 23	11 18 32.8	52.73	16 06.05	66	15 35.67		0 16.4	6 16.1	12 37.98
Sat. 24	11 39 33.2	52.30	16 06.32	66	15 43.81		0 12.5	6 12.2	12 38.33
Sun. 25	12 00 23.1	51.85	16 06.59	66	15 51.25		0 08.6	6 08.3	12 38.69
Mon. 26	12 21 01.8	51.38	16 06.86	66	15 57.99		0 04.7	6 04.4	12 39.08
Tues. 27	12 41 29.1	50.89	16 07.13	66	16 04.02		{0 00.7 A.M. / 11 56.8 P.M.}	E.E. 6 00.4 P.M.	{12 39.49 / 12 39.92}
Wed. 28	13 01 44.5	50.38	16 07.39	66	16 09.33		11 52.9	W.E. 5 53.2 A.M.	12 40.35
Thur. 29	13 21 47.6	49.86	16 07.66	66	16 13.90		11 49.0	5 49.3	12 40.78
Fri. 30	13 41 37.9	49.32	16 07.92	67	16 17.74		11 45.0	5 45.3	12 41.19
Sat. 31	S14 01 15.1	−48.77	16 08.19	67	16 20.81		11 41.1 P.M.	W.E. 5 41.4 A.M.	12 41.58
NOVEMBER, 1987									
Sun. 1	S14 20 38.8	−48.20	16 08.45	67	16 23.12		11 37.2 P.M.	W.E. 5 37.5 A.M.	12 41.95
Mon. 2	14 39 48.5	47.61	16 08.70	67	16 24.64		11 33.2	5 33.5	12 42.29
Tues. 3	14 58 44.0	47.01	16 08.96	67	16 25.38		11 29.3	5 29.6	12 42.63
Wed. 4	15 17 24.8	46.39	16 09.21	67	16 25.31		11 25.4	5 25.7	12 42.96
Thur. 5	15 35 50.6	45.75	16 09.45	67	16 24.42		11 21.4	5 21.7	12 43.31
Fri. 6	15 54 01.0	45.10	16 09.70	67	16 22.71		11 17.5	5 17.8	12 43.67
Sat. 7	16 11 55.6	44.44	16 09.94	68	16 20.17		11 13.6	5 13.9	12 44.04
Sun. 8	16 29 34.1	43.76	16 10.17	68	16 16.78		11 09.7	5 10.0	12 44.44
Mon. 9	16 46 56.0	43.06	16 10.40	68	16 12.54		11 05.7	5 06.0	12 44.84
Tues. 10	17 04 01.0	42.35	16 10.63	68	16 07.44		11 01.8	5 02.1	12 45.25
Wed. 11	17 20 48.6	41.61	16 10.86	68	16 01.48		10 57.9	4 58.2	12 45.66
Thur. 12	17 37 18.5	40.87	16 11.08	68	15 54.65		10 53.9	4 54.2	12 46.06
Fri. 13	17 53 30.2	40.10	16 11.30	68	15 46.96		10 50.0	4 50.3	12 46.45
Sat. 14	18 09 23.3	39.32	16 11.51	68	15 38.40		10 46.1	4 46.4	12 46.83
Sun. 15	18 24 57.5	38.52	16 11.73	68	15 28.98		10 42.1	4 42.4	12 47.18
Mon. 16	S18 40 12.3	−37.70	16 11.94	69	15 18.69		10 38.2 P.M.	W.E. 4 38.5 A.M.	12 47.52

The sign − prefixed to the hourly change of declination indicates that {south / north} declinations are {increasing. / decreasing.}

For time of Eastern Elongation of Polaris for any date after October 27th, subtract $5^h\ 56.4^m$ from the time of Upper Culmination of the same date.

TO FIND THE LATITUDE BY AN ALTITUDE OBSERVATION OF POLARIS AT ANY HOUR ANGLE, 1987

Mean Time Hour Angle	Primary Adjustment to Elevation of Pole								Mean Time Hour Angle
	Subtract Polaris Above the Pole				Add Polaris Below the Pole				
	Decl. +89°				Decl. +89°				
	12′ 10″	12′ 30″	12′ 50″	13′ 10″	12′ 10″	12′ 30″	12′ 50″	13′ 10″	
h m	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	h m
0 00.0	0 47 50	0 47 30	0 47 10	0 46 50	0 00 00	0 00 00	0 00 00	0 00 00	5 57.4
					0 00 20	0 00 20	0 00 19	0 00 19	5 59.0
0 12.0	0 47 46	0 47 26	0 47 06	0 46 46	0 01 35	0 01 34	0 01 33	0 01 33	6 05.0
23.9	47 34	47 14	46 54	46 34	02 50	02 49	02 47	02 46	11.0
35.9	47 14	46 54	46 35	46 15	04 05	04 03	04 01	04 00	17.0
47.9	46 46	46 27	46 07	45 48	05 20	05 17	05 15	05 13	23.0
59.8	46 11	45 52	45 32	45 13	06 34	06 31	06 28	06 26	28.9
1 11.8	0 45 28	0 45 09	0 44 50	0 44 31	0 07 48	0 07 45	0 07 42	0 07 38	6 34.9
23.8	44 37	44 18	44 00	43 41	09 02	08 58	08 55	08 51	40.9
35.7	43 39	43 20	43 02	42 44	10 16	10 11	10 07	10 03	46.9
47.7	42 33	42 15	41 58	41 40	11 29	11 24	11 19	11 14	52.9
59.7	41 21	41 03	40 46	40 29	12 41	12 36	12 31	12 25	58.9
2 11.6	0 40 01	0 39 44	0 39 28	0 39 11	0 13 54	0 13 48	0 13 42	0 13 36	7 04.8
23.6	38 35	38 19	38 03	37 47	15 05	14 59	14 52	14 46	10.8
35.6	37 03	36 47	36 32	36 16	16 16	16 09	16 02	15 55	16.8
47.5	35 24	35 09	34 54	34 40	17 26	17 19	17 11	17 04	22.8
59.5	33 39	33 25	33 11	32 57	18 35	18 28	18 20	18 12	28.8
3 05.5	0 32 45	0 32 32	0 32 18	0 32 04	0 19 44	0 19 36	0 19 27	0 19 19	7 34.8
11.5	31 49	31 36	31 23	31 10	20 52	20 43	20 34	20 25	40.7
17.5	30 52	30 40	30 27	30 14	21 59	21 50	21 40	21 31	46.7
23.4	29 54	29 42	29 29	29 17	23 05	22 55	22 45	22 36	52.7
29.4	28 55	28 43	28 31	28 19	24 10	24 00	23 50	23 39	58.7
3 35.4	0 27 54	0 27 42	0 27 31	0 27 19	0 25 14	0 25 04	0 24 53	0 24 42	8 04.7
41.4	26 52	26 41	26 30	26 19	26 17	26 06	25 55	25 44	10.7
47.4	25 49	25 38	25 28	25 17	27 19	27 08	26 56	26 45	16.6
53.4	24 45	24 35	24 25	24 14	28 20	28 08	27 56	27 44	22.6
59.3	23 40	23 30	23 21	23 11	29 20	29 07	28 55	28 43	28.6
4 05.3	0 22 34	0 22 25	0 22 15	0 22 06	0 30 18	0 30 06	0 29 53	0 29 40	8 34.6
11.3	21 27	21 18	21 09	21 01	31 16	31 02	30 49	30 36	40.6
17.3	20 19	20 11	20 03	19 54	32 12	31 58	31 44	31 31	46.6
23.3	19 11	19 03	18 55	18 47	33 06	32 52	32 38	32 24	52.5
29.3	18 01	17 54	17 46	17 39	33 59	33 45	33 31	33 17	58.5
4 35.2	0 16 51	0 16 44	0 16 37	0 16 30	0 35 42	0 35 27	0 35 12	0 34 57	9 10.5
41.2	15 40	15 34	15 27	15 21	37 18	37 03	36 47	36 31	22.5
47.2	14 29	14 23	14 17	14 11	38 49	38 33	38 16	38 00	34.4
53.2	13 17	13 11	13 06	13 01	40 13	39 56	39 39	39 22	46.4
59.2	12 04	11 59	11 54	11 49	41 31	41 13	40 56	40 38	58.4
5 05.2	0 10 51	0 10 47	0 10 42	0 10 38	0 42 41	0 42 23	0 42 06	0 41 48	10 10.3
11.1	09 38	09 34	09 30	09 26	43 45	43 27	43 09	42 50	22.3
17.1	08 24	08 20	08 17	08 14	44 42	44 23	44 05	43 46	34.3
23.1	07 10	07 07	07 04	07 01	45 31	45 12	44 53	44 34	46.2
29.1	05 55	05 53	05 50	05 48	46 14	45 54	45 35	45 16	58.2
5 35.1	0 04 40	0 04 38	0 04 37	0 04 35	0 46 48	0 46 29	0 46 09	0 45 49	11 10.2
41.1	03 25	03 24	03 23	03 21	47 15	46 55	46 36	46 16	22.1
47.0	02 10	02 10	02 09	02 08	47 34	47 15	46 55	46 35	34.1
53.0	00 55	00 55	00 55	00 54	47 46	47 26	47 06	46 46	46.1
57.4	00 00	00 00	00 00	00 00	47 50	47 30	47 10	46 50	58.0

Mean Time Hour Angle	Supplemental Correction to be Applied to the Vertical Angle Reading													Mean Time Hour Angle
	Altitude													
	10°	15°	20°	25°	30°	35°	40°	45°	50°	55°	60°	65°	70°	
h m	″	″	″	″	″	″	″	″	″	″	″	″	″	h m
0 00	0	0	0	0	0	0	0	0	0	0	0	0	0	11 58
1 00	− 1	− 1	− 1	− 1	− 1	− 0	− 0	0	+ 0	+ 1	+ 1	+ 1	+ 2	10 58
2 00	4	4	3	3	2	− 1	− 1	0	1	2	4	6	9	9 58
3 00	8	7	6	5	4	3	2	0	2	4	7	11	17	8 58
3 59	12	11	9	8	6	4	2	0	3	6	11	17	26	7 59
4 59	15	13	12	10	8	5	3	0	3	8	13	21	32	6 59
5 59	−16	−14	−12	−10	− 8	− 6	− 3	0	+ 4	+ 8	+14	+22	+34	5 59

Lat.	Correction to the Time of Elongation	AZIMUTH OF POLARIS AT ELONGATION, 1987						
		Decl. +89°						
		12′ 10″	12′ 20″	12′ 30″	12′ 40″	12′ 50″	13′ 00″	13′ 10″
° ′	W.E. m E.E.	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
10 00	+2.1−	0 48 34	0 48 24	0 48 14	0 48 04	0 47 54	0 47 44	0 47 33
12 00	2.0	0 48 54	0 48 44	0 48 34	0 48 23	0 48 13	0 48 03	0 47 53
14 00	1.9	0 49 18	0 49 08	0 48 57	0 48 47	0 48 37	0 48 26	0 48 16
16 00	1.7	0 49 46	0 49 35	0 49 25	0 49 14	0 49 04	0 48 54	0 48 43
18 00	1.6	0 50 18	0 50 07	0 49 57	0 49 46	0 49 36	0 49 25	0 49 15
20 00	1.5	0 50 54	0 50 44	0 50 33	0 50 22	0 50 12	0 50 01	0 49 50
21 00	1.4	0 51 14	0 51 03	0 50 53	0 50 42	0 50 31	0 50 21	0 50 10
22 00	1.4	0 51 35	0 51 25	0 51 14	0 51 03	0 50 52	0 50 41	0 50 31
23 00	1.3	0 51 58	0 51 47	0 51 36	0 51 25	0 51 14	0 51 04	0 50 53
24 00	1.2	0 52 22	0 52 11	0 52 00	0 51 49	0 51 38	0 51 27	0 51 16
25 00	1.2	0 52 47	0 52 36	0 52 25	0 52 14	0 52 03	0 51 52	0 51 41
26 00	1.1	0 53 13	0 53 02	0 52 51	0 52 40	0 52 29	0 52 18	0 52 06
27 00	1.0	0 53 41	0 53 30	0 53 19	0 53 07	0 52 56	0 52 45	0 52 34
28 00	1.0	0 54 11	0 53 59	0 53 48	0 53 37	0 53 25	0 53 14	0 53 03
29 00	0.9	0 54 41	0 54 30	0 54 19	0 54 07	0 53 56	0 53 44	0 53 33
30 00	0.8	0 55 14	0 55 02	0 54 51	0 54 39	0 54 28	0 54 16	0 54 05
31 00	0.8	0 55 48	0 55 37	0 55 25	0 55 13	0 55 02	0 54 50	0 54 38
32 00	0.7	0 56 24	0 56 12	0 56 01	0 55 49	0 55 37	0 55 25	0 55 14
33 00	0.6	0 57 02	0 56 50	0 56 38	0 56 26	0 56 14	0 56 03	0 55 51
34 00	0.5	0 57 42	0 57 30	0 57 18	0 57 06	0 56 54	0 56 42	0 56 30
35 00	0.4	0 58 24	0 58 11	0 57 59	0 57 47	0 57 35	0 57 23	0 57 10
36 00	0.4	0 59 08	0 58 55	0 58 43	0 58 30	0 58 18	0 58 06	0 57 53
37 00	0.3	0 59 54	0 59 41	0 59 29	0 59 16	0 59 04	0 58 51	0 58 39
38 00	0.2	1 00 42	1 00 29	1 00 17	1 00 04	0 59 51	0 59 39	0 59 26
39 00	+0.1−	1 01 33	1 01 20	1 01 07	1 00 54	1 00 42	1 00 29	1 00 16
40 00	0.0	1 02 27	1 02 14	1 02 00	1 01 47	1 01 34	1 01 21	1 01 08
41 00	−0.1+	1 03 23	1 03 10	1 02 56	1 02 43	1 02 30	1 02 17	1 02 03
42 00	0.2	1 04 22	1 04 09	1 03 55	1 03 42	1 03 28	1 03 15	1 03 01
43 00	0.3	1 05 24	1 05 11	1 04 57	1 04 43	1 04 30	1 04 16	1 04 02
44 00	0.4	1 06 30	1 06 16	1 06 02	1 05 48	1 05 34	1 05 20	1 05 06
45 00	0.5	1 07 39	1 07 25	1 07 11	1 06 56	1 06 42	1 06 28	1 06 14
46 00	0.6	1 08 52	1 08 37	1 08 23	1 08 08	1 07 54	1 07 40	1 07 25
47 00	0.7	1 10 08	1 09 54	1 09 39	1 09 24	1 09 10	1 08 55	1 08 40
48 00	0.9	1 11 29	1 11 14	1 10 59	1 10 44	1 10 30	1 10 15	1 10 00
49 00	1.0	1 12 55	1 12 40	1 12 24	1 12 09	1 11 54	1 11 39	1 11 23
50 00	1.1	1 14 25	1 14 10	1 13 54	1 13 38	1 13 23	1 13 07	1 12 52
51 00	1.3	1 16 01	1 15 45	1 15 29	1 15 13	1 14 57	1 14 41	1 14 25
52 00	1.4	1 17 42	1 17 26	1 17 09	1 16 53	1 16 37	1 16 21	1 16 04
53 00	1.5	1 19 29	1 19 13	1 18 56	1 18 39	1 18 23	1 18 06	1 17 49
54 00	1.7	1 21 23	1 21 06	1 20 49	1 20 32	1 20 15	1 19 58	1 19 41
55 00	1.9	1 23 24	1 23 07	1 22 49	1 22 32	1 22 14	1 21 57	1 21 39
55 30	1.9	1 24 27	1 24 10	1 23 52	1 23 34	1 23 17	1 22 59	1 22 41
56 00	2.0	1 25 33	1 25 15	1 24 57	1 24 39	1 24 21	1 24 03	1 23 45
56 30	2.1	1 26 40	1 26 22	1 26 04	1 25 46	1 25 28	1 25 10	1 24 52
57 00	2.2	1 27 50	1 27 32	1 27 13	1 26 55	1 26 36	1 26 18	1 26 00
57 30	2.3	1 29 02	1 28 43	1 28 25	1 28 06	1 27 47	1 27 29	1 27 10
58 00	2.4	1 30 16	1 29 57	1 29 39	1 29 20	1 29 01	1 28 42	1 28 23
58 30	2.5	1 31 33	1 31 14	1 30 55	1 30 36	1 30 17	1 29 58	1 29 38
59 00	2.6	1 32 53	1 32 33	1 32 14	1 31 55	1 31 35	1 31 16	1 30 56
59 30	2.7	1 34 15	1 33 56	1 33 36	1 33 16	1 32 56	1 32 37	1 32 17
60 00	2.8	1 35 41	1 35 21	1 35 01	1 34 41	1 34 21	1 34 01	1 33 41
60 30	2.9	1 37 09	1 36 49	1 36 28	1 36 08	1 35 48	1 35 27	1 35 07
61 00	3.1	1 38 40	1 38 20	1 37 59	1 37 39	1 37 18	1 36 57	1 36 37
61 30	3.2	1 40 15	1 39 54	1 39 33	1 39 13	1 38 52	1 38 31	1 38 10
62 00	3.3	1 41 54	1 41 33	1 41 11	1 40 50	1 40 29	1 40 07	1 39 46
62 30	3.4	1 43 36	1 43 15	1 42 53	1 42 31	1 42 10	1 41 48	1 41 26
63 00	3.6	1 45 23	1 45 00	1 44 38	1 44 16	1 43 54	1 43 32	1 43 10
63 30	3.7	1 47 13	1 46 51	1 46 28	1 46 06	1 45 43	1 45 21	1 44 58
64 00	3.8	1 49 08	1 48 45	1 48 22	1 47 59	1 47 37	1 47 14	1 46 51
64 30	4.0	1 51 07	1 50 44	1 50 21	1 49 58	1 49 34	1 49 11	1 48 48
65 00	4.1	1 53 12	1 52 48	1 52 25	1 52 01	1 51 37	1 51 14	1 50 50
65 30	4.3	1 55 22	1 54 58	1 54 34	1 54 09	1 53 45	1 53 21	1 52 57
66 00	4.5	1 57 37	1 57 13	1 56 48	1 56 24	1 55 59	1 55 34	1 55 10
66 30	4.6	1 59 59	1 59 34	1 59 09	1 58 43	1 58 18	1 57 53	1 57 28
67 00	4.8	2 02 27	2 02 01	2 01 35	2 01 10	2 00 44	2 00 18	1 59 53
67 30	5.0	2 05 01	2 04 35	2 04 09	2 03 43	2 03 16	2 02 50	2 02 24
68 00	5.2	2 07 43	2 07 16	2 06 49	2 06 23	2 05 56	2 05 29	2 05 03
68 30	5.4	2 10 32	2 10 05	2 09 38	2 09 11	2 08 43	2 08 16	2 07 49
69 00	5.6	2 13 30	2 13 02	2 12 34	2 12 07	2 11 39	2 11 11	2 10 43
69 30	5.8	2 16 37	2 16 08	2 15 40	2 15 11	2 14 43	2 14 14	2 13 46
70 00	−6.0+	2 19 53	2 19 24	2 18 55	2 18 26	2 17 56	2 17 27	2 16 58

EXPLANATIONS FOR THE STELLAR OBSERVATIONS

The data in this Ephemeris are arranged for the surveying practice of the Bureau of Land Management; the methods are useful in any survey where field observations are to be made for the ascertainment of the direction of a line in terms of angular value referred to the true meridian at that place.

In most cases, data are available as to the approximate latitude and longitude of the observing station, and preliminary determinations are made for the meridian and watch correction in terms of local mean time. The observations of the stars then follow on an observing program arranged for what is needed, and to suit the time of year, the latitude of the station, and other conditions that are factors.

A complete and well balanced stellar observing program will include: (1) the meridian passage of one star for time and latitude; (2) Polaris for azimuth and latitude; and (3) two well placed stars, one easterly and one westerly, both for azimuth, and one or both for time. The necessary verifications are thus accomplished. Instrumental uncertainties in the vertical angle readings are made apparent by this plan, and are compensated by taking the means of offsetting values. An observation may be made to verify only one or two values when the remainder are already well determined.

There are six stellar observing periods: (1) late afternoon, daylight; (2) early evening, twilight; (3) later p. m., after dark, illumination required; (4) after midnight, ditto; (5) early morning, twilight; and (6) after sunrise, daylight. The stars to be observed are chosen after deciding upon the observing period, and making the selection according to the desired position in hour angle and declination.

The time of a star's transit is to be reduced from the tabulated value for the Greenwich meridian to the longitude of the station; this is 10 seconds of time for each 15° (or one hour) of longitude, subtracted for west longitude (see table of Sidereal Conversions, page 27); this will give the correct local mean time at the moment of the star's meridian passage. The next step is to anticipate the probable local mean time of each observation, and the star's hour angle at that moment, to the east or to the west of the meridian.

The setting positions for the instrument in vertical angle (v) and in horizontal angle (A) are computed on the basis of the assumed hour angle (t), the star's declination (δ), and the known or approximate latitude (φ). This is done to secure a setting that is sufficiently accurate to bring the star within the field of the telescope, especially if the observation is to be by daylight, or twilight; less accuracy is needed just for the star's identification if the observation is to be made during starlight. The preliminary computations may be made with 4-place tables. The true values are obtained by reduction of the observations. The reductions for stellar observations are similar to the methods applicable to observations of the sun, and employ the same equations.

In all stellar observations, the true vertical angle (h) is equal to the observed vertical angle (v) minus the refraction (r) in zenith distance; there is no correction for parallax. In observations of the sun, the true vertical angle (h) is equal to (v) minus (r) plus parallax; see table, page 25.

In observations of the sun, the meridian passage and the hour angle (t) are in apparent solar time. The equation of time is applied to give the watch correction in terms of local mean time.

In observations of a star, the hour angle (t) is in terms of a sidereal rate; a subtraction of 10 seconds per hour will give the equivalent mean time hour angle. (Sidereal Conversions, page 27).

The following equations are regarded as the most useful for the methods stated above:

On the meridian, the vertical angle: $h = 90° - \varphi \pm \delta$; (or) $\varphi = 90° - h \pm \delta$

At any hour angle: $\sin h = \cos t \cos \varphi \cos \delta + \sin \varphi \sin \delta$

$$: \cos t = \frac{\sin h}{\cos \varphi \cos \delta} - \tan \varphi \tan \delta$$

$$: \cos A = \frac{\sin \delta}{\cos \varphi \cos h} - \tan \varphi \tan h$$

The product "$\sin \varphi \sin \delta$" and the fraction "$\frac{\sin \delta}{\cos \varphi \cos h}$" are negative for south declinations.

The product "$\cos t \cos \varphi \cos \delta$" is negative for hour angles exceeding six hours or 90°.

The product "$\tan \varphi \tan \delta$" is subtracted for north declinations; added for south declinations.

If the result for "cos A" is $\left\{\begin{matrix}\text{positive}\\ \text{negative}\end{matrix}\right\}$ the horizontal angle counts from the $\left\{\begin{matrix}\text{north.}\\ \text{south.}\end{matrix}\right.$

If the result for "cos t" is $\left\{\begin{matrix}\text{positive}\\ \text{negative}\end{matrix}\right\}$ the hour angle is $\left\{\begin{matrix}\text{less}\\ \text{more}\end{matrix}\right\}$ than six hours or 90°.

By a stellar equal-altitude observation, the meridian is determined as the mean of two direction-pointings; the latitude is not required; there are no corrections as to declination. A mean of the watch readings at the moment of each observation is equivalent to a reading at the time of the star's meridian passage. The latitude may be reduced from the maximum vertical angle at meridian passage.

The equations as written and explained above are applicable for the northern latitudes; suitable transpositions are required for observations in the southern latitudes.

Apparent Altitude	Ref
° ′	
7 30	
7 40	
7 50	
8 0	
8 10	
8 20	
8 30	
8 40	
8 50	
9 0	
9 10	
9 20	
9 30	
9 40	
9 50	
10 0	
10 20	
10 40	
11 0	
11 20	
11 40	
12 0	

Apparent altitu
Sun's true alti
Star's true alt

COEFF

Barometer (Ins.)	Elevation above sea le (Feet
30.5	-451
30.2	-181
30.0	00
29.9	+ 91
29.6	366
29.3	643
29.0	924
28.7	1,207
28.4	1,493
28.1	1,783
27.8	2,075
27.5	2,371
27.2	2,670

MEAN REFRACTIONS IN ZENITH DISTANCE AND SUN'S PARALLAX IN ALTITUDE
Bar. : 29.6 ins. Temp. : 50° F.

Apparent Altitude	Refraction	Sun's Par.	Apparent Altitude	Refraction	Sun's Par.	Apparent Altitude	Refraction	Sun's Par.
° ′	′ ″	″	° ′	′ ″	″	°	′ ″	″
7 30	6 53	8.8	12 0	4 25	8.7	25	2 3	8.1
7 40	6 45	8.8	12 30	4 15	8.7	26	1 58	8.0
7 50	6 37	8.8	13 0	4 5	8.7	27	1 53	7.9
8 0	6 30	8.8	13 30	3 56	8.7	28	1 48	7.9
8 10	6 22	8.8	14 0	3 47	8.6	29	1 44	7.8
8 20	6 15	8.8	14 30	3 39	8.6	30	1 40	7.7
8 30	6 8	8.8	15 0	3 32	8.6	32	1 32	7.6
8 40	6 2	8.8	15 30	3 25	8.6	34	1 25	7.4
8 50	5 55	8.8	16 0	3 19	8.6	36	1 19	7.2
9 0	5 49	8.8	16 30	3 13	8.5	38	1 14	7.0
9 10	5 43	8.8	17 0	3 7	8.5	40	1 9	6.8
9 20	5 38	8.8	17 30	3 1	8.5	42	1 4	6.6
9 30	5 32	8.8	18 0	2 56	8.5	44	1 0	6.4
9 40	5 26	8.8	18 30	2 51	8.4	46	0 56	6.2
9 50	5 21	8.8	19 0	2 46	8.4	48	0 52	6.0
10 0	5 16	8.8	19 30	2 42	8.4	50	0 48	5.7
10 20	5 6	8.8	20 0	2 37	8.4	55	0 40	5.1
10 40	4 57	8.7	21 0	2 29	8.3	60	0 33	4.4
11 0	4 48	8.7	22 0	2 22	8.2	65	0 27	3.8
11 20	4 40	8.7	23 0	2 15	8.2	70	0 21	3.0
11 40	4 32	8.7	24 0	2 9	8.1	80	0 10	1.5
12 0	4 25	8.7	25 0	2 3	8.1	90	0 0	0.0

Apparent altitude (observed vertical angle) : v
Sun's true altitude : h = v - refraction + parallax
Star's true altitude : h = v - refraction

True refraction : mean refraction x coefficient for barometric pressure x coefficient for temperature.

COEFFICIENTS TO APPLY TO MEAN REFRACTIONS FOR VARIATIONS IN BAROMETER AND TEMPERATURE

Barometer (Ins.)	Elevation above sea level (Feet)	Coefficient	Barometer (Ins.)	Elevation above sea level (Feet)	Coefficient	Barometer (Ins.)	Elevation above sea level (Feet)	Coefficient	Temperature (Fahr.)	Coefficient
30.5	-451	1.03	27.2	2,670	0.92	23.6	6,538	0.80	-10°	1.13
30.2	-181	1.02	26.9	2,972	.91	23.3	6,887	.79	0°	1.11
30.0	00	1.01	26.6	3,277	.90	23.0	7,239	.78	+10°	1.08
29.9	+ 91	1.01	26.3	3,586	.89	22.7	7,597	.77	20°	1.06
29.6	366	1.00	26.0	3,899	.88	22.4	7,960	.76	30°	1.04
29.3	643	.99	25.7	4,215	.87	22.1	8,327	.75	40°	1.02
29.0	924	.98	25.4	4,535	.86	21.8	8,700	.74	50°	1.00
28.7	1,207	.97	25.1	4,859	.85	21.5	9,077	.73	60°	.98
28.4	1,493	.96	24.8	5,186	.84	21.2	9,460	.72	70°	.96
28.1	1,783	.95	24.5	5,518	.83	20.9	9,848	.71	80°	.94
27.8	2,075	.94	24.2	5,854	.82	20.6	10,242	.70	90°	.93
27.5	2,371	.93	23.9	6,194	.81	20.3	10,642	.69	100°	.91
27.2	2,670	.92	23.6	6,538	.80	20.0	11,047	.68	+110°	.90

CONVERSION OF ARC TO TIME

° ′	h m m s	° ′	h m m s	°	h m	°	h m	°	h m	°	h m	″	s
0	0 00	30	2 00	60	4 00	90	6 00	120	8 00	150	10 00	0	0,00
1	0 04	31	2 04	61	4 04	91	6 04	121	8 04	151	10 04	2	0,13
2	0 08	32	2 08	62	4 08	92	6 08	122	8 08	152	10 08	4	0,27
3	0 12	33	2 12	63	4 12	93	6 12	123	8 12	153	10 12	6	0,40
4	0 16	34	2 16	64	4 16	94	6 16	124	8 16	154	10 16	8	0,53
5	0 20	35	2 20	65	4 20	95	6 20	125	8 20	155	10 20	10	0,67
6	0 24	36	2 24	66	4 24	96	6 24	126	8 24	156	10 24	12	0,80
7	0 28	37	2 28	67	4 28	97	6 28	127	8 28	157	10 28	14	0,93
8	0 32	38	2 32	68	4 32	98	6 32	128	8 32	158	10 32	16	1,07
9	0 36	39	2 36	69	4 36	99	6 36	129	8 36	159	10 36	18	1,20
10	0 40	40	2 40	70	4 40	100	6 40	130	8 40	160	10 40	20	1,33
11	0 44	41	2 44	71	4 44	101	6 44	131	8 44	161	10 44	22	1,47
12	0 48	42	2 48	72	4 48	102	6 48	132	8 48	162	10 48	24	1,60
13	0 52	43	2 52	73	4 52	103	6 52	133	8 52	163	10 52	26	1,73
14	0 56	44	2 56	74	4 56	104	6 56	134	8 56	164	10 56	28	1,87
15	1 00	45	3 00	75	5 00	105	7 00	135	9 00	165	11 00	30	2,00
16	1 04	46	3 04	76	5 04	106	7 04	136	9 04	166	11 04	32	2,13
17	1 08	47	3 08	77	5 08	107	7 08	137	9 08	167	11 08	34	2,27
18	1 12	48	3 12	78	5 12	108	7 12	138	9 12	168	11 12	36	2,40
19	1 16	49	3 16	79	5 16	109	7 16	139	9 16	169	11 16	38	2,53
20	1 20	50	3 20	80	5 20	110	7 20	140	9 20	170	11 20	40	2,67
21	1 24	51	3 24	81	5 24	111	7 24	141	9 24	171	11 24	42	2,80
22	1 28	52	3 28	82	5 28	112	7 28	142	9 28	172	11 28	44	2,93
23	1 32	53	3 32	83	5 32	113	7 32	143	9 32	173	11 32	46	3,07
24	1 36	54	3 36	84	5 36	114	7 36	144	9 36	174	11 36	48	3,20
25	1 40	55	3 40	85	5 40	115	7 40	145	9 40	175	11 40	50	3,33
26	1 44	56	3 44	86	5 44	116	7 44	146	9 44	176	11 44	52	3,47
27	1 48	57	3 48	87	5 48	117	7 48	147	9 48	177	11 48	54	3,60
28	1 52	58	3 52	88	5 52	118	7 52	148	9 52	178	11 52	56	3,73
29	1 56	59	3 56	89	5 56	119	7 56	149	9 56	179	11 56	58	3,87
30	2 00	60	4 00	90	6 00	120	8 00	150	10 00	180	12 00	60	4,00

Degrees of arc convert to hours and minutes of time ; minutes of arc convert to minutes and seconds of time . See right hand column for conversion of seconds of arc to seconds of time .

SIDEREAL CONVERSIONS

		Longitude						
		0° 00′	2° 30′	5° 00′	7° 30′	10° 00′	12° 30′	15° 00′
		Minutes						
Long.	Hours	0	10	20	30	40	50	60
°		m s	m s	m s	m s	m s	m s	m s
0	0	0 00	0 02	0 03	0 05	0 07	0 08	0 10
15	1	0 10	0 11	0 13	0 15	0 16	0 18	0 20
30	2	0 20	0 21	0 23	0 25	0 26	0 28	0 30
45	3	0 30	0 31	0 33	0 34	0 36	0 38	0 39
60	4	0 39	0 41	0 43	0 44	0 46	0 48	0 49
75	5	0 49	0 51	0 53	0 54	0 56	0 57	0 59
90	6	0 59	1 01	1 02	1 04	1 06	1 07	1 09
105	7	1 09	1 11	1 12	1 14	1 15	1 17	1 19
120	8	1 19	1 20	1 22	1 24	1 25	1 27	1 29
135	9	1 29	1 30	1 32	1 34	1 35	1 37	1 38
150	10	1 38	1 40	1 42	1 43	1 45	1 47	1 48
165	11	1 48	1 50	1 52	1 53	1 55	1 56	1 58
180	12	1 58	2 00	2 01	2 03	2 05	2 06	2 08

Sidereal into mean solar time : To be subtracted from a sidereal time interval : Argument , hours and minutes of sidereal interval .

Mean solar into sidereal time : To be added to a mean time interval : Argument , hours and minutes of mean time interval .

For any stellar observation : Amount to be subtracted from the Greenwich mean time of transit or elongation to obtain local mean time : Argument , longitude west from Greenwich ; add for longitudes east from Greenwich .

Mean Time Hour Angle	AZIMUTH OF POLARIS AT ALL HOUR ANGLES, 1987											CORR. TO AZIMUTH		
	Mean Declination + 89° 12′ 40″											Add for Decl. + 89°		
												12′30″	12′20″	12′10″
	Latitude											Subtract for Decl. + 89°		
	30°	32°	34°	36°	38°	40°	42°	44°	46°	48°	50°	12′50″	13′00″	13′10″
h m	′	′	′	′	′	′	′	′	′	′	′	′	′	′
0 00.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0 10.0	2.4	2.5	2.5	2.6	2.6	2.7	2.8	2.9	3.0	3.1	3.3	0.0	0.0	0.0
19.9	4.8	4.9	5.0	5.2	5.3	5.4	5.6	5.8	6.0	6.3	6.5	0.0	0.0	0.1
29.9	7.2	7.3	7.5	7.7	7.9	8.2	8.4	8.7	9.0	9.4	9.8	0.0	0.1	0.1
0 39.9	9.6	9.8	10.0	10.3	10.5	10.9	11.2	11.6	12.0	12.5	13.0	0.0	0.1	0.1
49.9	11.9	12.2	12.5	12.8	13.1	13.5	14.0	14.4	15.0	15.5	16.2	0.0	0.1	0.1
59.8	14.3	14.6	14.9	15.3	15.7	16.2	16.7	17.3	17.9	18.6	19.4	0.1	0.1	0.2
1 09.8	16.6	16.9	17.3	17.8	18.3	18.8	19.4	20.0	20.8	21.6	22.5	0.1	0.1	0.2
19.8	18.8	19.2	19.7	20.2	20.8	21.4	22.0	22.8	23.6	24.5	25.6	0.1	0.2	0.2
29.8	21.1	21.5	22.0	22.6	23.2	23.9	24.7	25.5	26.4	27.5	28.6	0.1	0.2	0.3
1 39.7	23.3	23.8	24.3	25.0	25.6	26.4	27.2	28.1	29.2	30.3	31.6	0.1	0.2	0.3
49.7	25.4	26.0	26.6	27.3	28.0	28.8	29.7	30.7	31.9	33.1	34.5	0.1	0.2	0.3
59.7	27.5	28.1	28.8	29.5	30.3	31.2	32.2	33.3	34.5	35.8	37.4	0.1	0.2	0.3
2 09.6	29.6	30.2	30.9	31.7	32.6	33.5	34.6	35.8	37.1	38.5	40.1	0.1	0.2	0.4
19.6	31.6	32.2	33.0	33.8	34.8	35.8	36.9	38.2	39.5	41.1	42.8	0.1	0.3	0.4
29.6	33.5	34.2	35.0	35.9	36.9	38.0	39.2	40.5	42.0	43.6	45.4	0.1	0.3	0.4
2 39.6	35.3	36.1	37.0	37.9	38.9	40.1	41.3	42.7	44.3	46.0	47.9	0.1	0.3	0.4
49.5	37.1	37.9	38.8	39.8	40.9	42.1	43.4	44.9	46.5	48.3	50.4	0.1	0.3	0.4
59.5	38.9	39.7	40.6	41.7	42.8	44.1	45.4	47.0	48.7	50.6	52.7	0.2	0.3	0.5
3 09.5	40.5	41.4	42.4	43.4	44.6	45.9	47.4	49.0	50.7	52.7	54.9	0.2	0.3	0.5
19.5	42.1	43.0	44.0	45.1	46.3	47.7	49.2	50.8	52.7	54.7	57.0	0.2	0.3	0.5
29.4	43.6	44.5	45.6	46.7	48.0	49.4	50.9	52.6	54.5	56.6	59.0	0.2	0.3	0.5
3 39.4	45.0	45.9	47.0	48.2	49.5	51.0	52.5	54.3	56.3	58.5	60.9	0.2	0.4	0.5
49.4	46.3	47.3	48.4	49.6	51.0	52.4	54.1	55.9	57.9	60.2	62.7	0.2	0.4	0.6
59.3	47.5	48.5	49.7	50.9	52.3	53.8	55.5	57.4	59.4	61.7	64.3	0.2	0.4	0.6
4 09.3	48.7	49.7	50.9	52.1	53.5	55.1	56.8	58.7	60.8	63.2	65.8	0.2	0.4	0.6
19.3	49.7	50.8	51.9	53.2	54.7	56.3	58.0	60.0	62.1	64.5	67.2	0.2	0.4	0.6
29.3	50.6	51.7	52.9	54.3	55.7	57.3	59.1	61.1	63.3	65.7	68.5	0.2	0.4	0.6
4 39.2	51.5	52.6	53.8	55.2	56.7	58.3	60.1	62.1	64.3	66.8	69.6	0.2	0.4	0.6
49.2	52.3	53.4	54.6	56.0	57.5	59.1	61.0	63.0	65.3	67.8	70.6	0.2	0.4	0.6
59.2	52.9	54.0	55.3	56.7	58.2	59.9	61.7	63.8	66.1	68.6	71.4	0.2	0.4	0.6
5 09.2	53.5	54.6	55.9	57.2	58.8	60.5	62.3	64.4	66.7	69.3	72.1	0.2	0.4	0.6
19.1	53.9	55.0	56.3	57.7	59.3	61.0	62.9	64.9	67.3	69.8	72.7	0.2	0.4	0.6
29.1	54.2	55.4	56.7	58.1	59.6	61.4	63.2	65.3	67.7	70.3	73.2	0.2	0.4	0.6
5 39.1	54.5	55.6	56.9	58.3	59.9	61.6	63.5	65.6	68.0	70.6	73.5	0.2	0.4	0.7
49.0	54.6	55.8	57.1	58.5	60.0	61.8	63.7	65.8	68.1	70.7	73.6	0.2	0.4	0.7
55.3	...	...	...	...	...	...	...	...	...	...	73.6	0.3	0.5	0.8
5 55.5	...	...	...	...	...	...	...	...	...	70.7	...	0.2	0.5	0.7
55.8	...	...	...	...	...	...	...	...	68.1	...	...	0.2	0.5	0.7
56.0	...	...	...	...	...	...	...	65.8	...	...	...	0.2	0.5	0.7
5 56.2	...	...	...	...	...	...	63.7	...	...	...	...	0.2	0.4	0.7
56.4	...	...	...	...	...	61.8	...	...	...	...	...	0.2	0.4	0.7
56.6	...	...	...	...	60.1	...	...	...	...	...	...	0.2	0.4	0.6
5 56.7	...	...	...	58.5	...	...	...	...	...	...	...	0.2	0.4	0.6
56.9	...	...	57.1	...	...	...	...	...	...	...	...	0.2	0.4	0.6
57.1	...	55.8	...	...	...	...	...	...	...	...	...	0.2	0.4	0.6
5 57.2	54.7	...	...	...	...	...	...	...	...	...	...	0.2	0.4	0.6

Note: The equation shown on the opposite page may be employed when values in seconds are required, also for stations beyond the limits of the latitude tabulations, where:

A = Azimuth angle
t = Sidereal hour angle
ϕ = Latitude of station
δ = Declination of Polaris

Mean Time Hour Angle	AZIMUTH OF POLARIS AT ALL HOUR ANGLES, 1987											CORR. TO AZIMUTH		
	Mean Declination + 89° 12′ 40″											Add for Decl. + 89°		
												12′30″	12′20″	12′10″
	Latitude											Subtract for Decl. + 89°		
	30°	32°	34°	36°	38°	40°	42°	44°	46°	48°	50°	12′50″	13′00″	13′10″
h m	′	′	′	′	′	′	′	′	′	′	′	′	′	′
5 55.3	...	...	...	...	...	...	...	...	...	...	73.6	0.3	0.5	0.8
55.5	...	...	...	...	...	...	...	...	...	70.7	...	0.2	0.5	0.7
55.8	...	...	...	...	...	...	...	...	68.1	...	...	0.2	0.5	0.7
5 56.0	...	...	...	...	...	...	...	65.8	...	...	...	0.2	0.5	0.7
56.2	...	...	...	...	...	...	63.7	...	...	...	...	0.2	0.4	0.7
56.4	...	...	...	...	...	61.8	...	...	...	...	...	0.2	0.4	0.7
5 56.6	...	...	...	...	60.1	...	...	...	...	...	...	0.2	0.4	0.6
56.7	...	...	...	58.5	...	...	...	...	...	...	...	0.2	0.4	0.6
56.9	...	...	57.1	...	...	...	...	...	...	...	...	0.2	0.4	0.6
5 57.1	...	55.8	...	...	...	...	...	...	...	...	...	0.2	0.4	0.6
57.2	54.7	...	...	...	...	...	...	...	...	...	...	0.2	0.4	0.6
59.0	54.7	55.8	57.1	58.5	60.1	61.8	63.7	65.8	68.1	70.7	73.6	0.2	0.4	0.7
6 09.0	54.6	55.7	57.0	58.4	60.0	61.7	63.6	65.7	68.0	70.6	73.5	0.2	0.4	0.7
19.0	54.4	55.6	56.8	58.2	59.8	61.5	63.4	65.5	67.8	70.4	73.2	0.2	0.4	0.6
28.9	54.1	55.3	56.5	57.9	59.5	61.2	63.0	65.1	67.4	70.0	72.8	0.2	0.4	0.6
6 38.9	53.8	54.9	56.1	57.5	59.0	60.7	62.6	64.6	66.9	69.5	72.3	0.2	0.4	0.6
48.9	53.3	54.4	55.6	57.0	58.5	60.2	62.0	64.1	66.3	68.8	71.6	0.2	0.4	0.6
58.9	52.7	53.8	55.0	56.4	57.9	59.5	61.3	63.3	65.6	68.1	70.8	0.2	0.4	0.6
7 08.8	52.0	53.1	54.3	55.6	57.1	58.7	60.5	62.5	64.7	67.2	69.9	0.2	0.4	0.6
18.8	51.2	52.3	53.5	54.8	56.2	57.8	59.6	61.6	63.7	66.1	68.8	0.2	0.4	0.6
28.8	50.3	51.4	52.6	53.8	55.3	56.8	58.6	60.5	62.6	65.0	67.6	0.2	0.4	0.6
7 38.7	49.4	50.4	51.5	52.8	54.2	55.7	57.4	59.3	61.4	63.7	66.3	0.2	0.4	0.6
48.7	48.3	49.3	50.4	51.7	53.0	54.5	56.2	58.0	60.0	62.3	64.8	0.2	0.4	0.6
58.7	47.1	48.1	49.2	50.4	51.7	53.2	54.8	56.6	58.6	60.8	63.2	0.2	0.4	0.6
8 08.7	45.9	46.9	47.9	49.1	50.4	51.8	53.4	55.1	57.0	59.2	61.6	0.2	0.4	0.5
18.6	44.6	45.5	46.5	47.7	48.9	50.3	51.8	53.5	55.4	57.4	59.8	0.2	0.4	0.5
28.6	43.2	44.1	45.0	46.1	47.3	48.7	50.2	51.8	53.6	55.6	57.8	0.2	0.3	0.5
8 38.6	41.7	42.5	43.5	44.5	45.7	47.0	48.4	50.0	51.7	53.7	55.8	0.2	0.3	0.5
48.6	40.1	40.9	41.8	42.8	44.0	45.2	46.6	48.1	49.8	51.6	53.7	0.2	0.3	0.5
58.5	38.4	39.2	40.1	41.1	42.2	43.3	44.6	46.1	47.7	49.5	51.5	0.2	0.3	0.5
9 08.5	36.7	37.5	38.3	39.2	40.3	41.4	42.6	44.0	45.6	47.3	49.2	0.1	0.3	0.4
18.5	34.9	35.6	36.4	37.3	38.3	39.4	40.6	41.9	43.3	44.9	46.7	0.1	0.3	0.4
28.4	33.1	33.7	34.5	35.3	36.3	37.3	38.4	39.6	41.0	42.5	44.3	0.1	0.3	0.4
9 38.4	31.1	31.8	32.5	33.3	34.2	35.1	36.2	37.3	38.6	40.1	41.7	0.1	0.2	0.4
48.4	29.2	29.8	30.4	31.2	32.0	32.9	33.9	35.0	36.2	37.5	39.0	0.1	0.2	0.3
58.4	27.1	27.7	28.3	29.0	29.8	30.6	31.5	32.5	33.7	34.9	36.3	0.1	0.2	0.3
10 08.3	25.1	25.6	26.1	26.8	27.5	28.2	29.1	30.0	31.1	32.2	33.5	0.1	0.2	0.3
18.3	22.9	23.4	23.9	24.5	25.1	25.8	26.6	27.5	28.4	29.5	30.7	0.1	0.2	0.3
28.3	20.8	21.2	21.7	22.2	22.8	23.4	24.1	24.9	25.7	26.7	27.8	0.1	0.2	0.2
10 38.3	18.6	18.9	19.4	19.8	20.3	20.9	21.5	22.2	23.0	23.9	24.8	0.1	0.1	0.2
48.2	16.3	16.6	17.0	17.4	17.9	18.4	18.9	19.5	20.2	21.0	21.8	0.1	0.1	0.2
58.2	14.0	14.3	14.6	15.0	15.4	15.8	16.3	16.8	17.4	18.0	18.8	0.1	0.1	0.2
11 08.2	11.7	12.0	12.2	12.5	12.9	13.2	13.6	14.1	14.5	15.1	15.7	0.0	0.1	0.1
18.1	9.4	9.6	9.8	10.1	10.3	10.6	10.9	11.3	11.7	12.1	12.6	0.0	0.1	0.1
28.1	7.1	7.2	7.4	7.6	7.8	8.0	8.2	8.5	8.8	9.1	9.5	0.0	0.1	0.1
11 38.1	4.7	4.8	4.9	5.0	5.2	5.3	5.5	5.7	5.9	6.1	6.3	0.0	0.0	0.1
48.1	2.4	2.4	2.5	2.5	2.6	2.7	2.7	2.8	2.9	3.0	3.2	0.0	0.0	0.0
58.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

$$\text{Tan } A = \frac{\sin t}{\cos\phi \tan\delta - \sin\phi \cos t}$$

The product, $\sin\phi \cos t$, is subtracted for hour angles 0° to 90° and added for hour angles from 90° to 180°.

Time of WE. @ Greenwich Tues 3 NOV 87	5h 29.6m AM
Correction for Long. W of Greenwich (112.12 × 0.011 m)	− 1.2m
LCT of WE 3NOV 87 112° 07' W	5h 28.4m
Correction LCT to STANDARD Time (7.12 × 4m/deg)	+ 28.5m
MST of WE @ 112° 07' W	5h 56.9m AM

Time of U.C. @ Greenwich 3 NOV 87	11 h 29.3 m PM
Correction for LONG. (112.12 × 0.011 m)	− 1.2 m
LCT of UC @ 112° 07' W	11 h 28.1 m
LCT to STANDARD TIME (7.12 × 4 m)	+ 28.5 m
	11 h 56.6 m PM

Time of UC @ Greenwich 18 NOV 87	10 h 30.3 m P.M.
Correction for Longitude W of Greenwich 112°06' 45" (112.1125 × 0.011 m)	− 1.2
LCT OF UC 18 NOV 87 112° 06' 45"	10h 29.1m
Correction LCT to STANDARD Time (7.1125° × 4 m/deg)	28.45m
MST OF U.C.	10h 57.55m

POLAR DISTANCE

90° − DECLINATION

= 90° − 89° 12' 48" = 47' 12"

LATITUDE 34° 45' 14"

+ 47' 12"

35° 32' 26"

∴ AT 10:57:33 POLARIS AT Due North

ALTITUDE ≈ 90° − 35° 32' 26" = 54° 27' 34"

Time of W.E. @ Greenwich Wed 18 NOV 87	4:30.6 am
Correction for longitude W of Greenwich (112.12 × 0.011 m)	− 1.2
LCT of WE 18 NOV 87 112°07′ W	4h 29.4m am
Correction LCT to standard time (7.12 × 4 m/deg)	+ 28.5m
MST of WE @ 112°07′ W	4h 57.9m

Polar distance = 90° − declination

= 90° − 89°12′48″ = 0°47′12″

$$Z = \frac{P}{\cos \ell} = \frac{0°47'12''}{\cos 34°45'} = 0°57'27'' \text{ W of N}$$

BEARING N 0° 57′ 27″ W

POLARIS OBSERVATION 11/3/87 AJF

NOTES Longitude 112° 07' 00"

BS	IS	ANGLE RIGHT	VA	TIME	FS
S1	S2	88°43'35"	54°46'32"	7:15:30 pm	Polaris
		177° 36' 54"	305° 17' 36"	7:27:30 pm	Polaris
		[88° 48' 27"]			

CALCULATIONS:

Average VA:

90° − 54°46'32" = 35° 14' 28"

305° 17' 36" − 270° = 35° 17' 36"

35° 16' 02"
− 1' 10"
→ 35° 14' 52"

Correction for refraction − 1'22" × .86 × 1 = −70.5"

LOCAL HOUR ANGLE (LHA)

WATCH TIME November 3, 1987 7h 21m 30s

to 24 hr clock + 12

19 21m 30s

Correction for Time Zone (MST 7 hr west of Greenwich) + 7h

GCT 26h 21m 30s

GCT NOV 4, 1987 2h 21m 30s

Polaris Observation

Notes: 11/3/87 TEMP: 50°F ELEV. ≈ 4900 Long. 112°07'00"

BS	IS	ANGLE RT.	VA	TIME	FS
S1	S2	88°43'39"	54°46'32"	7:15:30	Polaris
		177°36'54"	305°17'36"	7:27:30	

Average ∡ RT = [88°48'27"]

Average VA = 90° − 54°46'32" = 35°14'28"
305°17'36" − 270° = 35°17'36"
} 35°16'02"

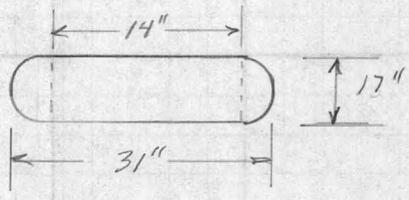
Hour Angle of Polaris, t

(Reference: Moffitt and Bouchard pg. 529)

MST Nov 3, 1987		19h	21m	30s
Longitude West of Greenwich	+	7h	0m	0s
Greenwich Civil Time Nov 3, 1987		26h	21m	30s
Mean Solar interval since 12h, Nov 3		14h	21m	30s
Correction to sidereal interval			+2m	11s
Sidereal interval since 12h, Nov 3		14h	23m	41s
S10 time Green 12h Nov 3	+	11h	43m	35s (from EPH. of SUN)
		25h	66m	76s
Greenwich Sidereal time of observa.		26h	07m	16s
Longitude to place of observation	−	7h	28m	28s
Local Sidereal time of observation		18h	38m	48s
Right Ascension to Polaris				

UVX 12/7/87

VENT Tube



FIND AREA $\frac{\pi 17^2}{4} + (14 \times 17) = 465 \text{ in}^2 = 3.23 \text{ FT}^2$

Length 230 FT

$\frac{2000 \text{ CFM}}{3.23} = 620 \text{ FPM}$

STAR SHOT DATA

11/3/87

BS	IS	FS	— ∡	⊥ ∡	TIME	
51	52	POLARIS	88° 43' 39"	54° 46' 32"	7:15:30	pm
			177° 36' 54"	302° 17' 36"	7:27:30	pm