SPIRAL CURVES MADE SIMPLE

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Spiral Curves Made Simple

- **HISTORY**
- Spiral curves were originally designed for the Railroads to smooth the transition from a tangent line into simple curves. They helped to minimize the wear and tear on the tracks. Spiral curves were implemented at a later date on highways to provide a smooth transition from the tangent line into simple curves. The highway engineers later determined that most drivers will naturally make that spiral transition with the vehicle; therefore, spiral curves are only used on highways in special cases today.

- Because they were used in the past and in special cases today, we need to know how to calculate them.

- From the surveyor's perspective, the design of spiral curves has already been determined by the engineer and will be documented on existing R/W and As-built plans. All we have to do is use the information shown on these plans to fit the spiral curve within our surveyed alignment.

- **REFERENCES**
- There are many books available on spiral curves that can help you know and understand how the design process works. It can get complicated when you dive into the theory and design of spiral curves.
- My reference material includes the following books:
- Railroad Curves and Earthwork; by C. Frank Allen, S.B.
- Route Surveying and Design; by Carl F. Meyer & David W. Gibson
- Surveying Theory and Practice; by Davis, Foote & Kelly

Spiral Curves Made Simple

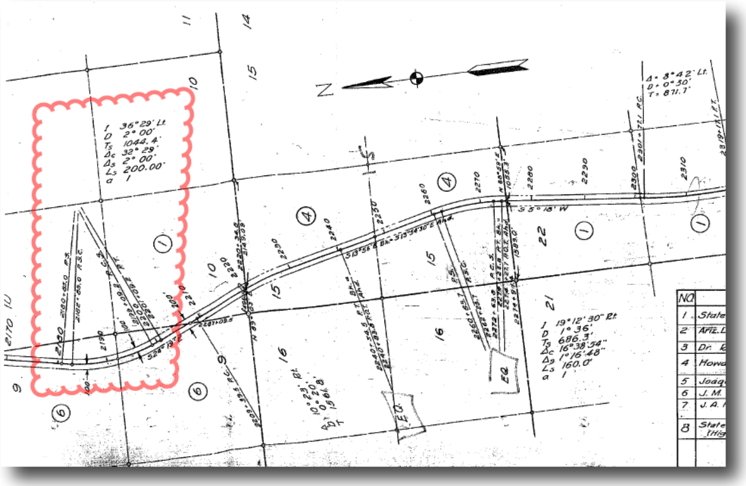
- **ADOT Roadway Guides for use in Office and Field 1986**
- This guide has all of the formulas and tables that you will need to work with spiral curves. The formulas, for the most part, are the same formulas used by the Railroad.
- The Railroads use the 10 Chord spiral method for layout and have tables setup to divide the spiral into 10 equal chords. Highway spirals can be laid out with the 10 Chord method but are generally staked out by centerline stationing depending on the needs in the field.
- For R/W calculations we only need to be concerned with the full spiral length.
- The tables that will be used the most are D-55.10 (Full Transition Spiral) and D-57.05 through D-57.95 (Transitional Spiral Tables).
- On rare occasions you may also need D-55.30 (Spiral Transition Compound Curves).

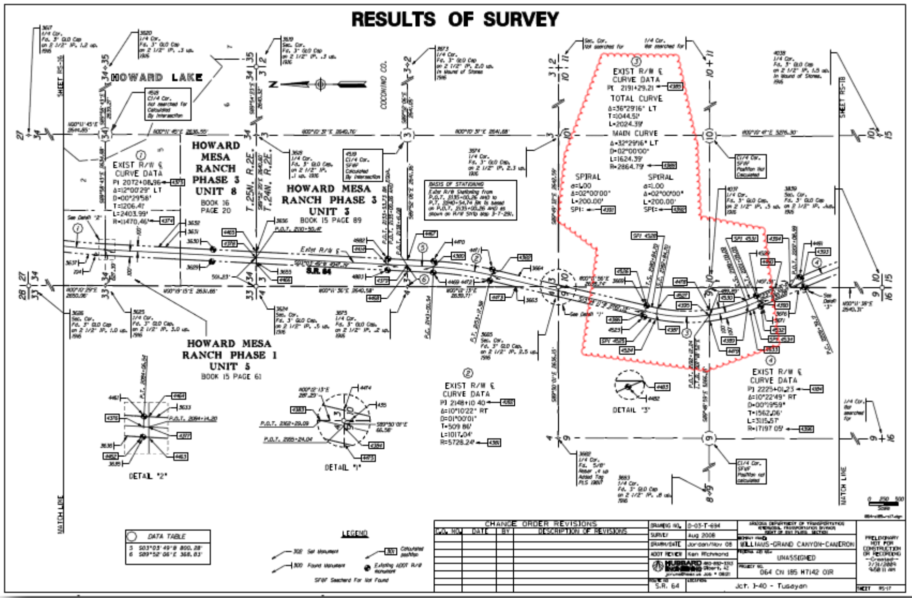
- **COURSE OBJECTIVE**
- This course is intended to introduce you to Spiral Curve calculations along centerline alignments.
- It is assumed that you already now how to calculate simple curves and generate coordinates from one point to another using a bearing and distance.
- Offsets to Spiral Curves and intersections of lines with Spiral Curves will not be discussed in this lesson. These types of calculations will be addressed in a future lesson.
- You can check your calculations using the online Spiral Calculator at:
- http://www.cc4w.net/spiral/index.aspx

- **EXAMPLE SPIRAL**
- Included are two example spiral curves from ADOT projects. The one that we will be calculating contains Equal Spirals for the Entrance and Exit on both sides of the main curve.
- The second example contains Unequal Spirals for the Entrance and Exit and a Transitional Spiral between two main curves with different radii. We will look at the process used to calculate this example but we will not be doing any calculations.
- The example spiral that we will be calculating is from the ADOT project along S.R. 64 as shown on sheet RS-17 of the Results of Survey.
- We will walk through each step to calculate this spiral.
- Note: My career started 30 plus years ago, before GPS and computers. I did all my calculations by hand and I teach my staff to do the calculations by hand so that they will have a thorough understanding of the mathematical process. I am a big advocate of technology and use it exclusively. I also have a passion for the art of surveying mathematics, therefore I feel that everyone should know how to do it manually. I feel that my staff has a better appreciation for technology by having done the calculations manually, at least once, before they rely on a computer to do it for them.

Spiral Curves Made Simple

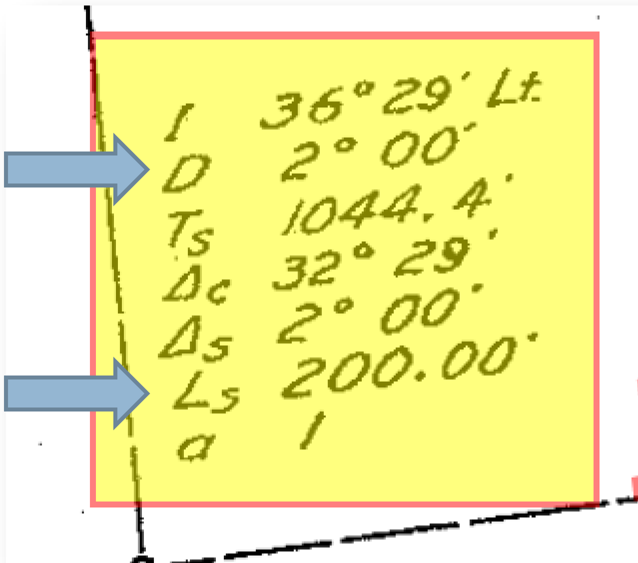
- **No. 1**
- Gather your known information for the spiral curve.

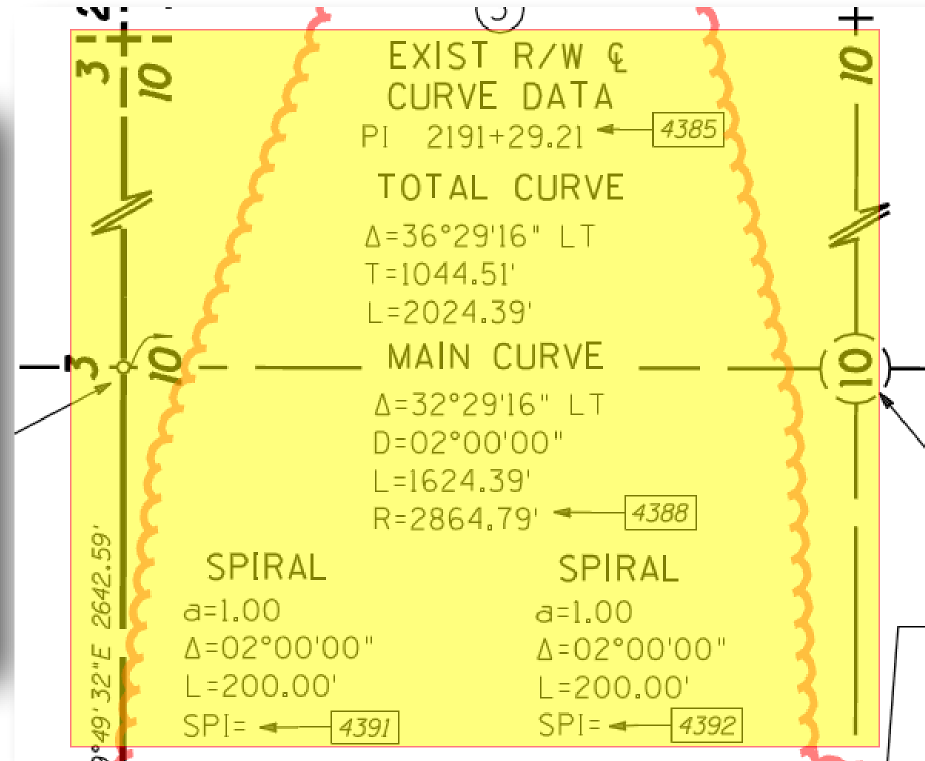




Spiral Curves Made Simple

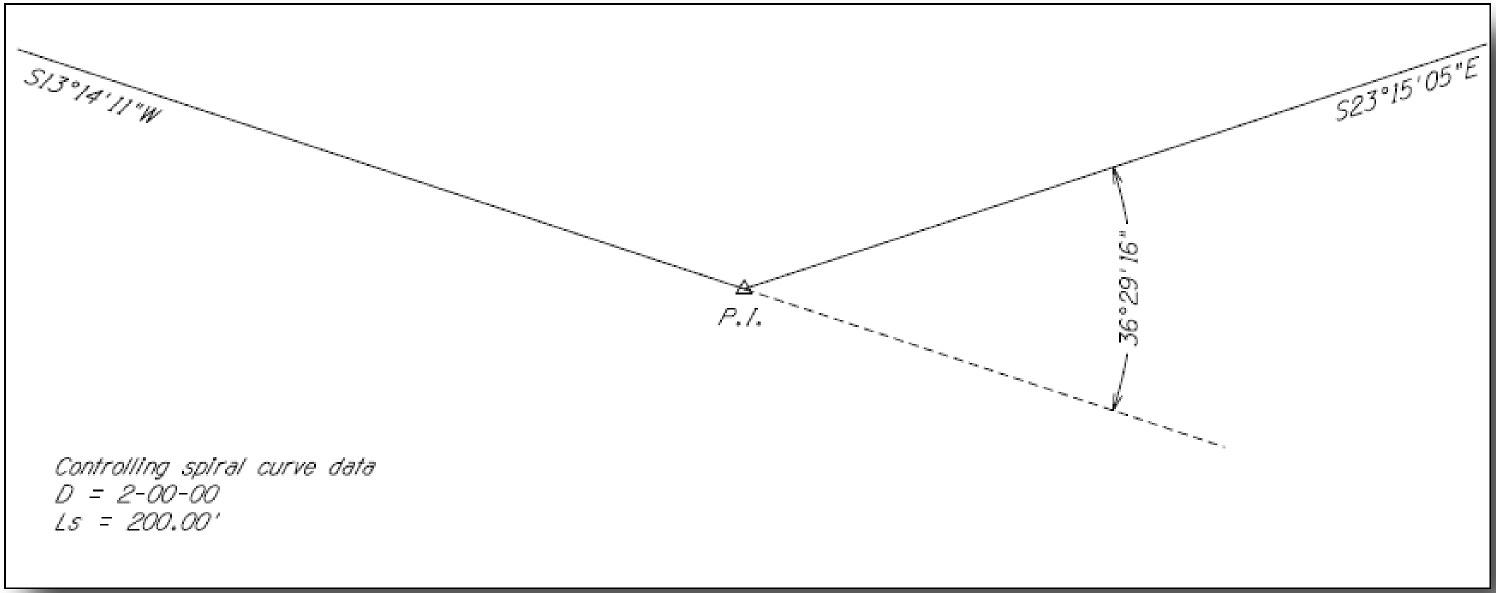
- Look for the spiral curve and main curve information





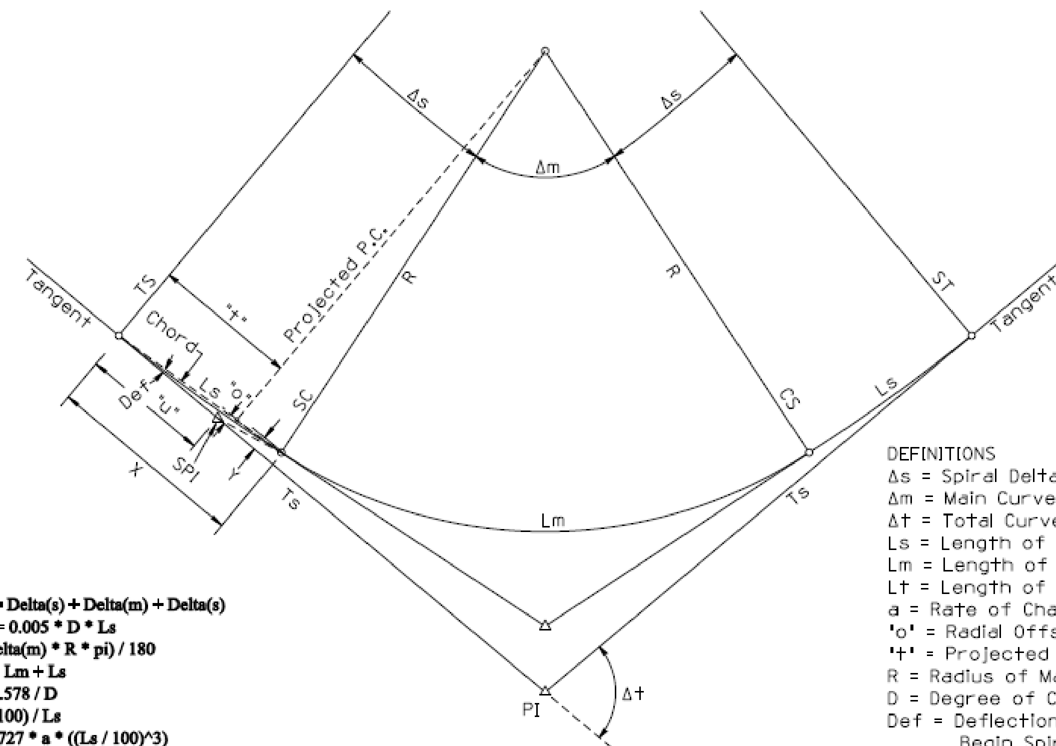
- The key information needed is the Degree of Curvature and the Spiral length.
- D=2°00'00" and Ls=200.00'

- **No. 2**
- Your tangent lines should be defined either by survey or record information. Sketch your tangent lines and Point of Intersection. Add the bearings for the tangent lines and calculate the deflection at the P.I. As shown below, the deflection is 36°29'16".
- 13°14'11" + 23°15'05" = 36°29'16"



Spiral Curves Made Simple

- **No. 3**
- The following are spiral formulas that have been derived from several reference materials for spiral calculations that will be utilized for this lesson.



Delta(t) = Delta(s) + Delta(m) + Delta(s)
Delta(s) = 0.005 * D * Ls
Lm = (Delta(m) * R * pi) / 180
Lt = Ls + Lm + Ls
R = 5729.578 / D
a = (D * 100) / Ls
"o" = 0.0727 * a * ((Ls / 100)^3)
"t" = (50 * Ls / 100) - (0.000127 * a^2 * (Ls / 100)^5)
Ts = (TAN(Delta(t) / 2) * (R + "o")) + "t" (In Degrees)
Chord = (100 * Ls / 100) - (0.00034 * a^2 * (Ls / 100)^5)
Def = (a * L^2)/ 60000
X = Chord * Cos(Def)
Y = Chord * Sin(Def)
"u" = Chord * Sin(Delta(s) * 2 / 3) / Sin(Delta(s))

SPIRAL DIAGRAM

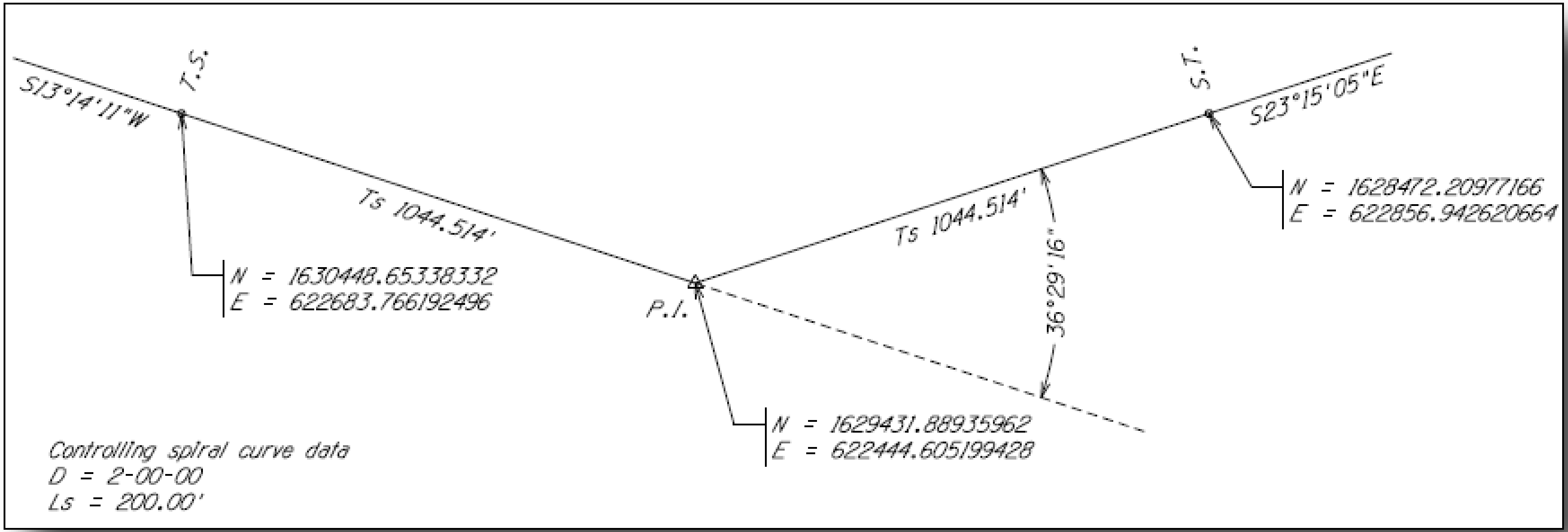
DEFINITIONS
Δs = Spiral Delta
Δm = Main Curve Delta
Δt = Total Curve Delta
Ls = Length of Spiral
Lm = Length of Main Curve
Lt = Length of Total Curve
a = Rate of Change per 100'
'o' = Radial Offset
't' = Projected curve P.C.
R = Radius of Main Curve
D = Degree of Curve
Def = Deflection from Begin Spiral
Ts = Tangent Length of Total Curve
PI = Point of Intersection of Total Curve
TS = Tangent to Spiral
SC = Spiral to Curve
CS = Curve to Spiral
ST = Spiral to Tangent

Spiral Curves Made Simple

- **No. 3 – continued**
- Next we will calculate the tangent distance (Ts) from the T.S. to the P.I.
- Use the following formulas to calculate Ts.
- Delta(t) = *36-29-16(dms) ~ 36.48777777(ddd)*
- D = *2-00-00(dms) ~ 2.0000(ddd)*
- Ls = *200.00'*
- R = 5729.578 / D = 5729.578 / 2.0000 = *2864.789'*
- a = (D * 100) / Ls = (2.0000 * 100) / 200.00 = *1.00* (Checks with record data)
- "o" = 0.0727 * a * ((Ls / 100)^3)
  - "o" = 0.0727 * 1 * ((200.00 / 100)^3) = *0.5816*
- "t" = (50 * Ls / 100) – (0.000127 * a^2 * (Ls / 100)^5)
  - "t" = (50 * 200.00/100) – (0.000127 * 1^2 * (200.00 / 100)^5 = *99.9959*
- Ts = (Tan(Delta(t) / 2) * (R +"o")) + "t"
  - Ts = (Tan(36.48777777 / 2) * (2864.789 + 0.5816)) + 99.9959 = *1044.515'*

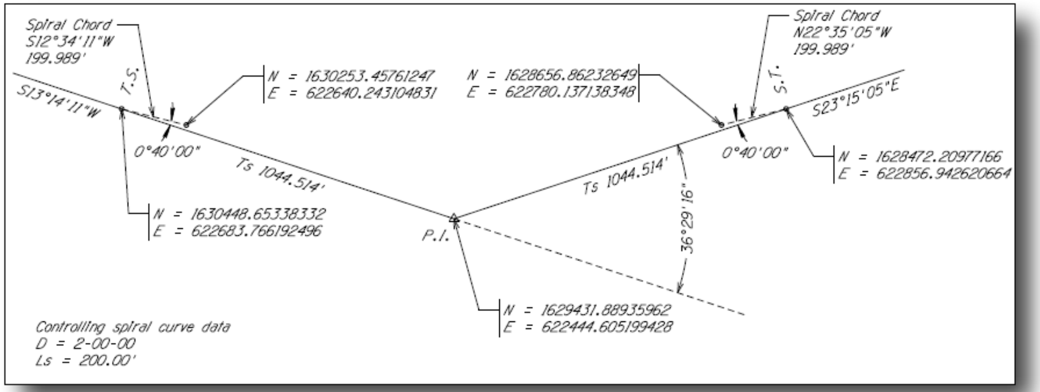
Spiral Curves Made Simple

- **No. 3 – continued**
- Calculate the Northing and Easting for the Tangent to Spiral (T.S.) & Spiral to Tangent (S.T.)
- Use coordinate geometry to calculate the Latitude and Departure for each course and add them to the Northing and Easting of the Point of Intersection (P.I.) to get the Northing and Easting for the T.S. and S.T.



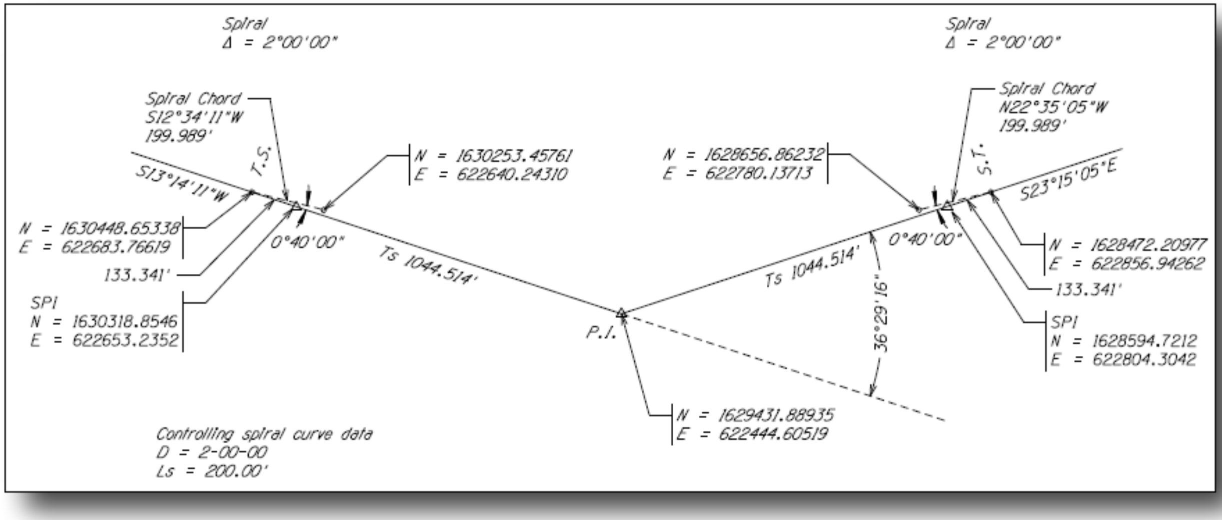
Spiral Curves Made Simple

- **No. 4**
- Calculate the spiral chord distance (Chord) and deflection angle (Def).
- Chord = (100 * Ls / 100) – (0.00034 * a^2 * (Ls / 100)^5)
  - Chord = (100 * 200.00 / 100) – (0.00034 * 1^2 * (200.00 / 100)^5) = <u>*199.989'*</u>
- Def = (a * Ls^2) / 60000 = (1 * 200.00^2) / 60000 = <u>*0.666666(ddd) ~ 0-40-00(dms)*</u>
- Calculate the chord bearing and Northing & Easting for the Spiral to Curve (S.C.) & Curve to Spiral (C.S.)
- Note: Substitute Ls for any length (L) along the spiral to calculate the sub-chord and Def angle to any point along the spiral from the T.S.



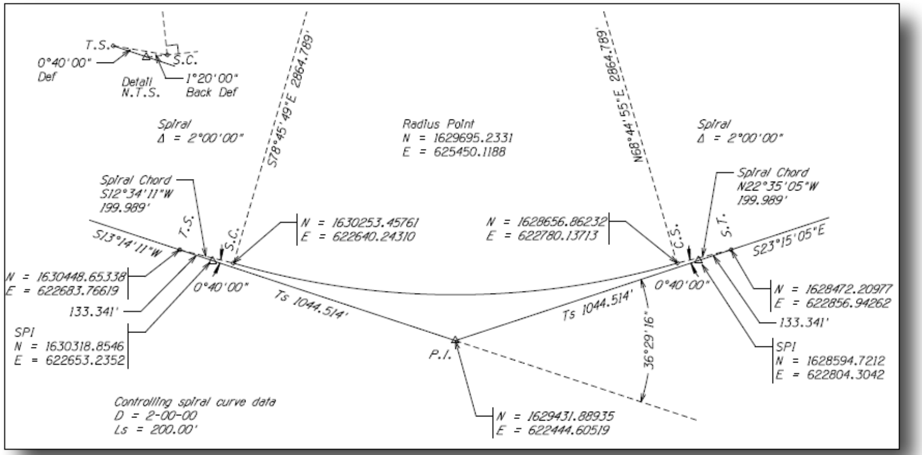
Spiral Curves Made Simple

- **No. 5**
- Calculate the spiral delta and tangent distance to the Spiral Point of Intersection (SPI).
- Delta(s) = 0.005 * D * Ls = 0.005 * 2.0000 * 200.00 = ***2.0000(ddd) ~ 2-00-00(dms)***
- "u" = Chord * Sin(Delta(s) * 2 / 3) / Sin(Delta(s))
  - "u" = 199.989 * Sin(2.0000 * 2 / 3) / Sin(2.0000) = ***133.341'***
- Calculate Northing and Easting of SPI.



Spiral Curves Made Simple

- **No. 6**
- Calculate the radial line and radius point for the main curve.
- Calculate the back deflection from the S.C. to the SPI is as follows:
- Delta(s) – Def = Back Def
  - 2.0000 – 0.666666 = 1.333334(ddd) ~ 1-20-00(dms)
- Using the Back Def and chord bearing calculate the tangent bearing at the S.C. then perpendicular from the tangent line calculate the radial line. Do this for the C.S. as well. Calculate the Radius point from the S.C. and C.S. You should come up with the same coordinates. If not, then something is wrong. Recheck all of your calculations.



Spiral Curves Made Simple

- **No. 7**
- Using the radial bearings calculate the Main Curve Delta of *32-29-16(dms) ~ 32.487777(dms)*
- Now add the Spiral Delta as follows:
- Delta(t) = Delta(s) + Delta(m) + Delta(s)
  - Delta(t) = 2-00-00 + 32-29-16 + 2-00-00 = *36-29-16* this should equal the deflection in Step 2.
- Calculate the arc length for Main Curve
- Lm = (Delta(m) * R * pi) / 180
  - Lm = (32.487777 * 2864.789 * 3.141592654) / 180 = *1624.389'*

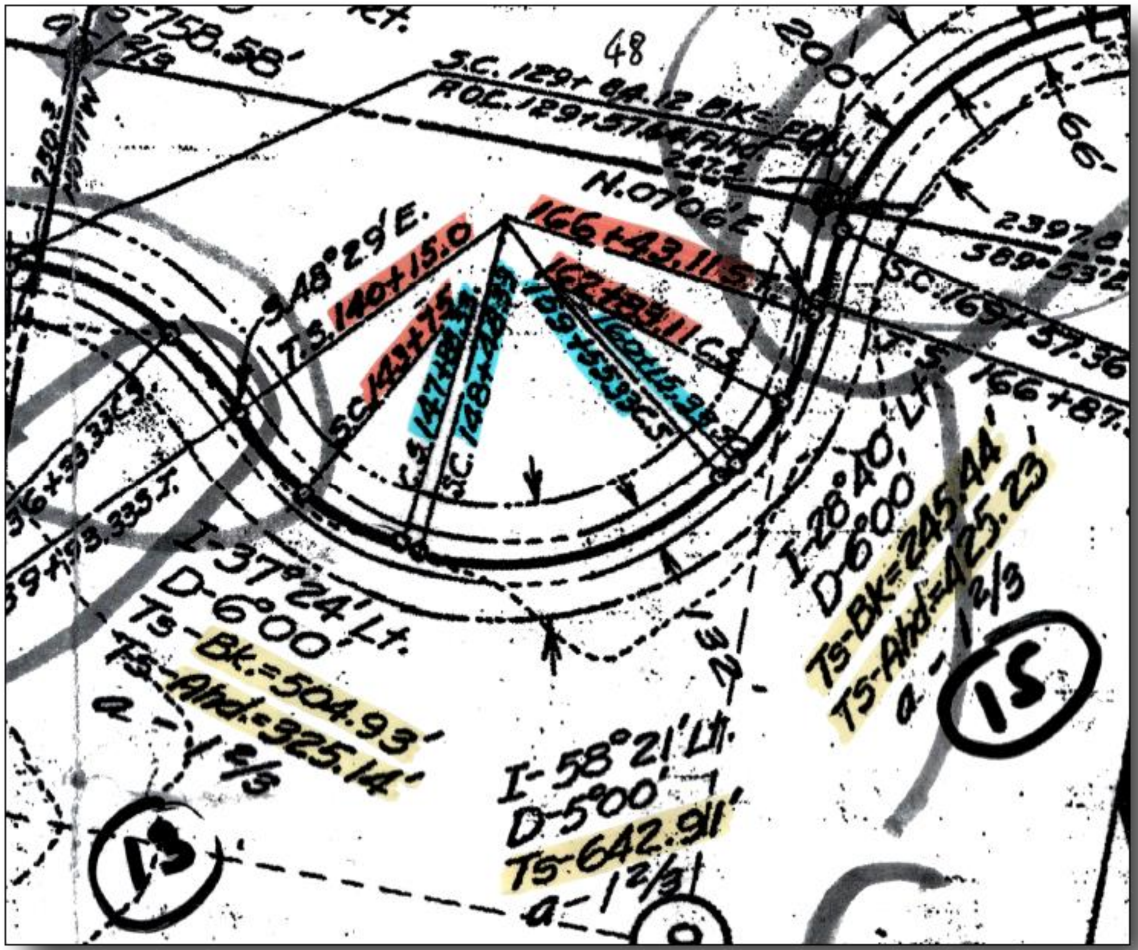
- **No. 8 – Almost done**
- The final step is to calculate the stationing.
- Starting with the T.S. calculate each stationing along the curve.
- T.S. 2180+84.70 + 200.00 (Ls) = *S.C. 2182+84.70*
- S.C. 2182+84.70 + 1624.39 (Lm) = *C.S. 2199+09.09*
- C.S. 2199+09.09 + 200.00 (Ls) = *S.T. 2201+09.09*

- P.I. Stationing = T.S. Stationing + Ts
- T.S. 2180+84.70 + 1044.51 (Ts) = *P.I. 2191+29.21*

- Be aware that you may have some slight differences in the coordinates, distances and stationing due to rounding errors.

- **Unequal Spiral information and Transitional Spirals**
- The following example is an ADOT project along U.S. 60 west of Globe AZ.
- The 10 miles section of highway is almost completely composed of spiral curves. There is one area that contained an entrance spiral, then a curve, then a transitional spiral, then a curve, then a transitional spiral, then a curve and finally an exit spiral.
- The next slide shows the record information for this segment.

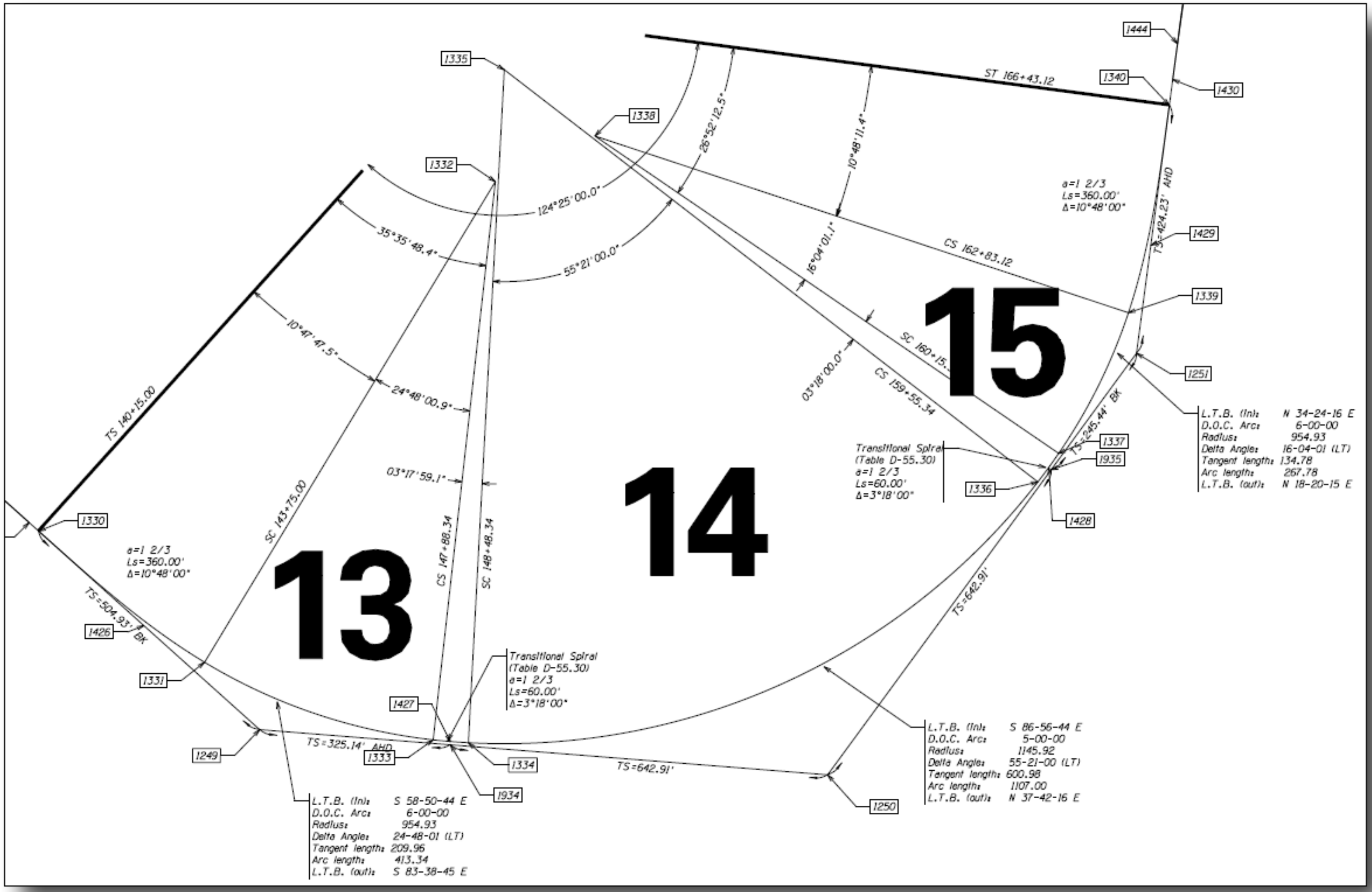
Spiral Curves Made Simple



Spiral Curves Made Simple

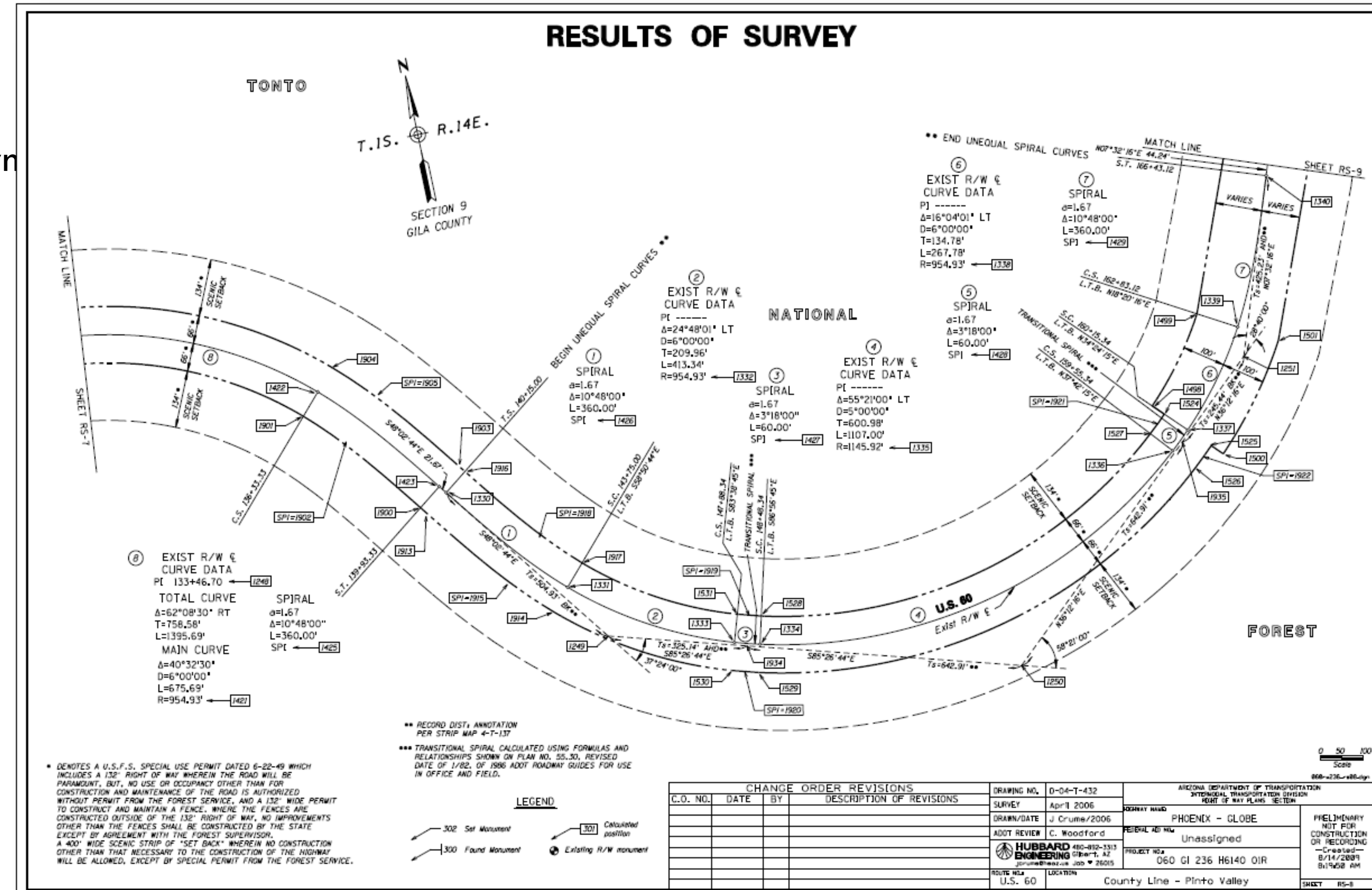
MicroStation tools and manual calculations were used to solve for curves 13, 14 & 15.

Table D-55.30 was used for the formulas needed to calculate the transitional spirals connecting the three main curves.



Spiral Curves Made Simple

Sheet RS-8 is how this multi-curve segment was shown on the Results of Survey



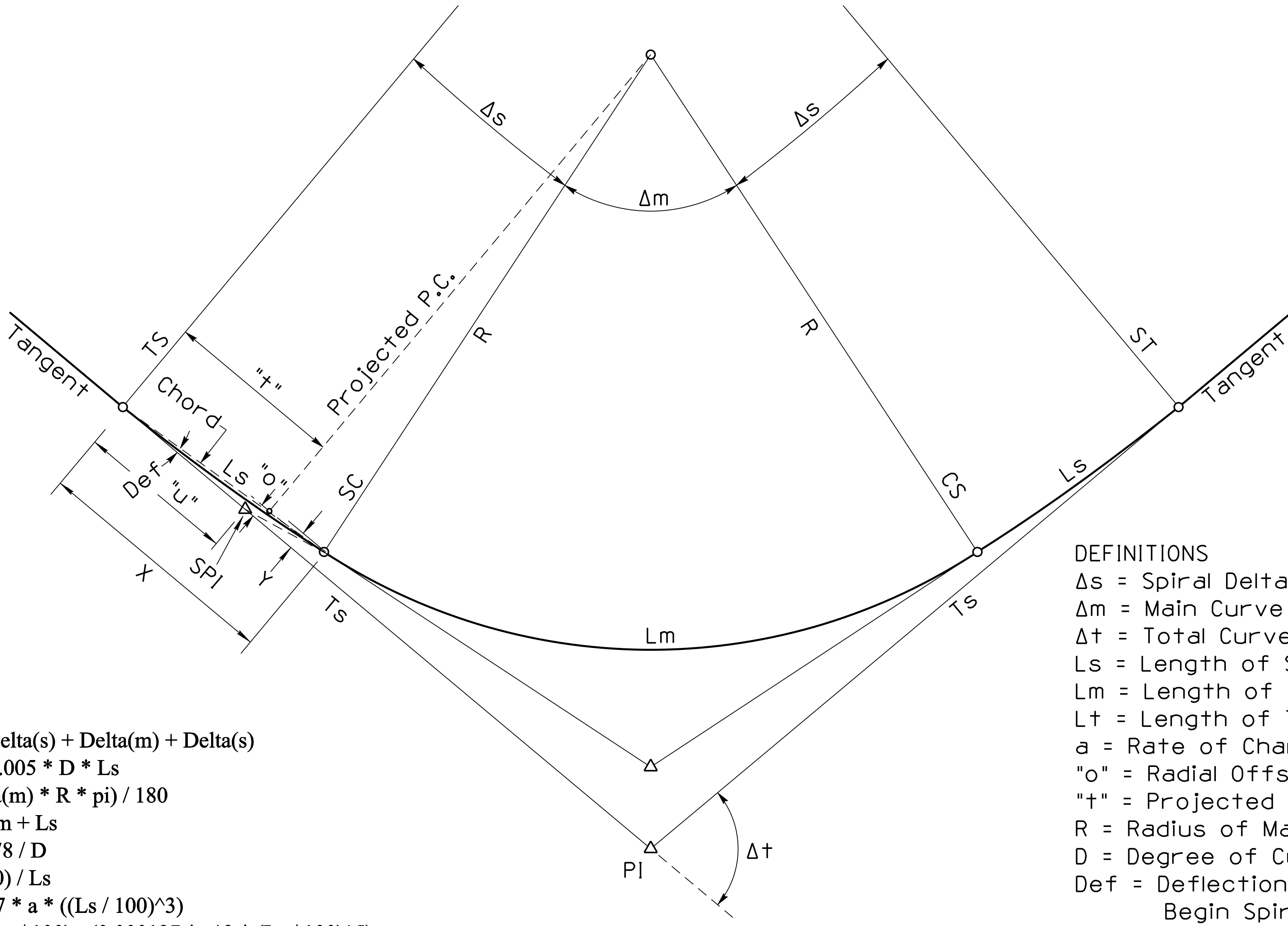
Calculating spiral curves does not have to be complicated. Once you understand the elements needed and methodically step through the process, you will obtain consistent results and might even have fun while doing it.

I hope that this presentation will debunk some of the myths that spiral curves are complicated and difficult to work with and will not make your hair turn gray.

You can contact me at jcrume@cc4w.net if you have any questions.

The Appendix contains full size PDF sheets that you can printout for your reference material.

APPENDIX



Delta(t) = Delta(s) + Delta(m) + Delta(s)
Delta(s) = 0.005 * D * Ls
Lm = (Delta(m) * R * pi) / 180
Lt = Ls + Lm + Ls
R = 5729.578 / D
a = (D * 100) / Ls
"o" = 0.0727 * a * ((Ls / 100)^3)
"t" = (50 * Ls / 100) - (0.000127 * a^2 * (Ls / 100)^5)
Ts = (TAN(Delta(t) / 2) * (R + "o")) + "t" (In Degrees)
Chord = (100 * Ls / 100) - (0.00034 * a^2 * (Ls / 100)^5)
Def = (a * L^2)/ 60000
X = Chord * Cos(Def)
Y = Chord * Sin(Def)
"u" = Chord * Sin(Delta(s) * 2 / 3) / Sin(Delta(s))

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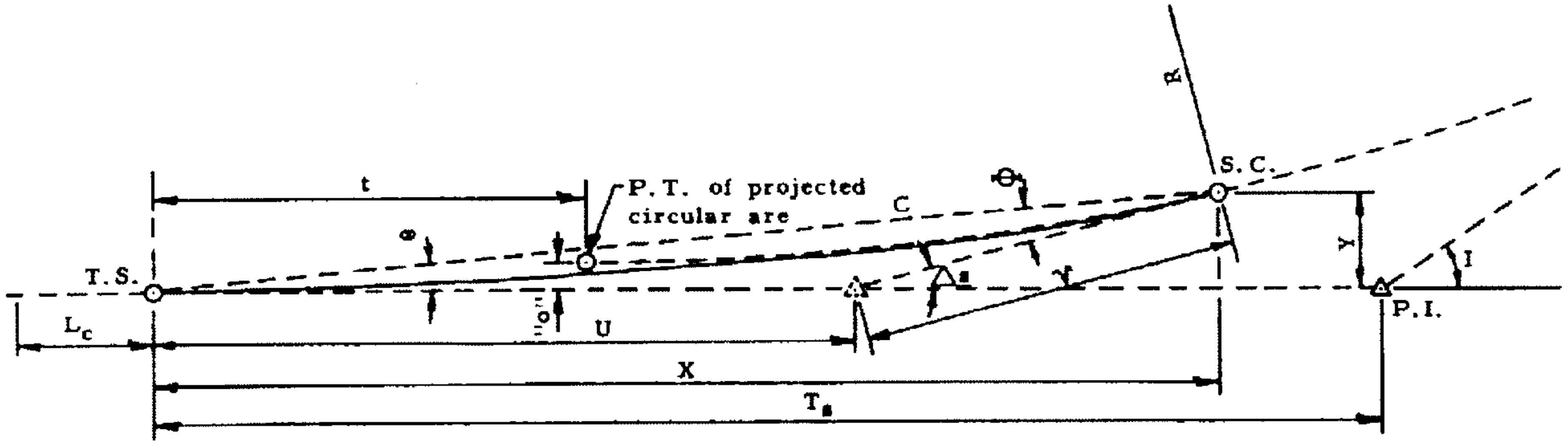
SPIRAL DIAGRAM

spiral.dgn



Determine values of L_s and a, for design speed and D, from Drwg. Nos. D-56.10 through D-56.30. These values may be checked by the following applicable formulae.

L_s(sta.) = Spiral distance from T.S. to S.C. = D/a

a(degrees) = Rate of change in degree of curvature per 100' of spiral = D/L_s

D(degrees) = Degree of curvature of circular curve $= aL_s = 5729.58/R$

R(ft.) = Radius of circular curve = 5729.58/D

"o"(ft.) = Radial offset $= 0.0727aL_s^3$

t(ft.) $= 50L_s - 0.000127a^2L_s^5$

Δ_s(degrees) = Full spiral deviation angle $= \frac{1}{2}aL_s^2 = \frac{1}{2}DL_s = \frac{1}{2}(D^2/a) = L_s/2(D)$

Θ(degrees) = Full spiral deflection angle at T. S. $= (1/3\Delta_s)^{\oplus} = 1/6aL_s^{2\oplus} = 1/6DL_s^{\oplus} = 1/6D^2/a^{\oplus}$

ϕ(degrees) = Full spiral deflection angle at S.C. $= \Delta_s - \Theta$

C(ft.) $= 100\ L_s - 0.00034a^2L_s^5$

V(ft.) $= C\sin\Theta/\sin\Delta_s$

U(ft.) $= C\sin\phi/\sin\Delta_s$

X(ft.) $= C\cos\Theta$

Y(ft.) $= C\sin\Theta$

T_s(ft.) $= [(\tan\frac{1}{2}I)(R+"o")] + t$

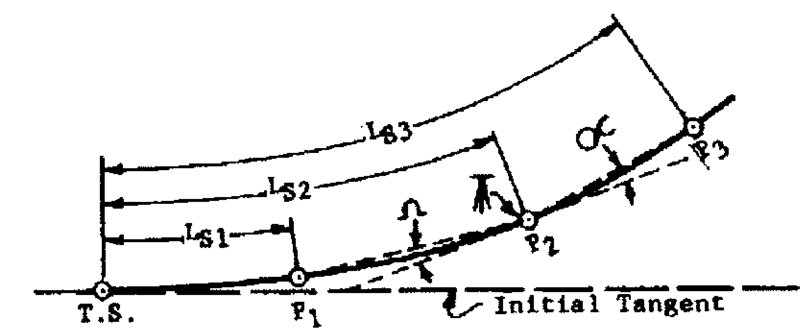
SPIRAL FORMULAE

Reduce Θ formulae values by C_n according to the following table:

Δ_s	C_n	Δ_s	C_n	Δ_s	C_n
16°	0.2'	31°	1.6'	46°	5.1'
17	0.3	32	1.7	47	5.5
18	0.3	33	1.9	48	5.8
19	0.4	34	2.1	49	6.2
20	0.4	35	2.3	50	6.6
21	0.5	36	2.5	51	7.0
22	0.6	37	2.7	52	7.4
23	0.6	38	2.9	53	7.9
24	0.7	39	3.1	54	8.3
25	0.8	40	3.4	55	8.8
26	0.9	41	3.6	56	9.3
27	1.0	42	3.9	57	9.8
28	1.2	43	4.2	58	10.3
29	1.3	44	4.5	59	10.8
30	1.4	45	4.8	60	11.4

$^{\oplus}$VALUES OF C_n IN Θ DETERMINATION FORMULAE

(C_n is negligible and may be ignored for Δ_s values less than 16°.)

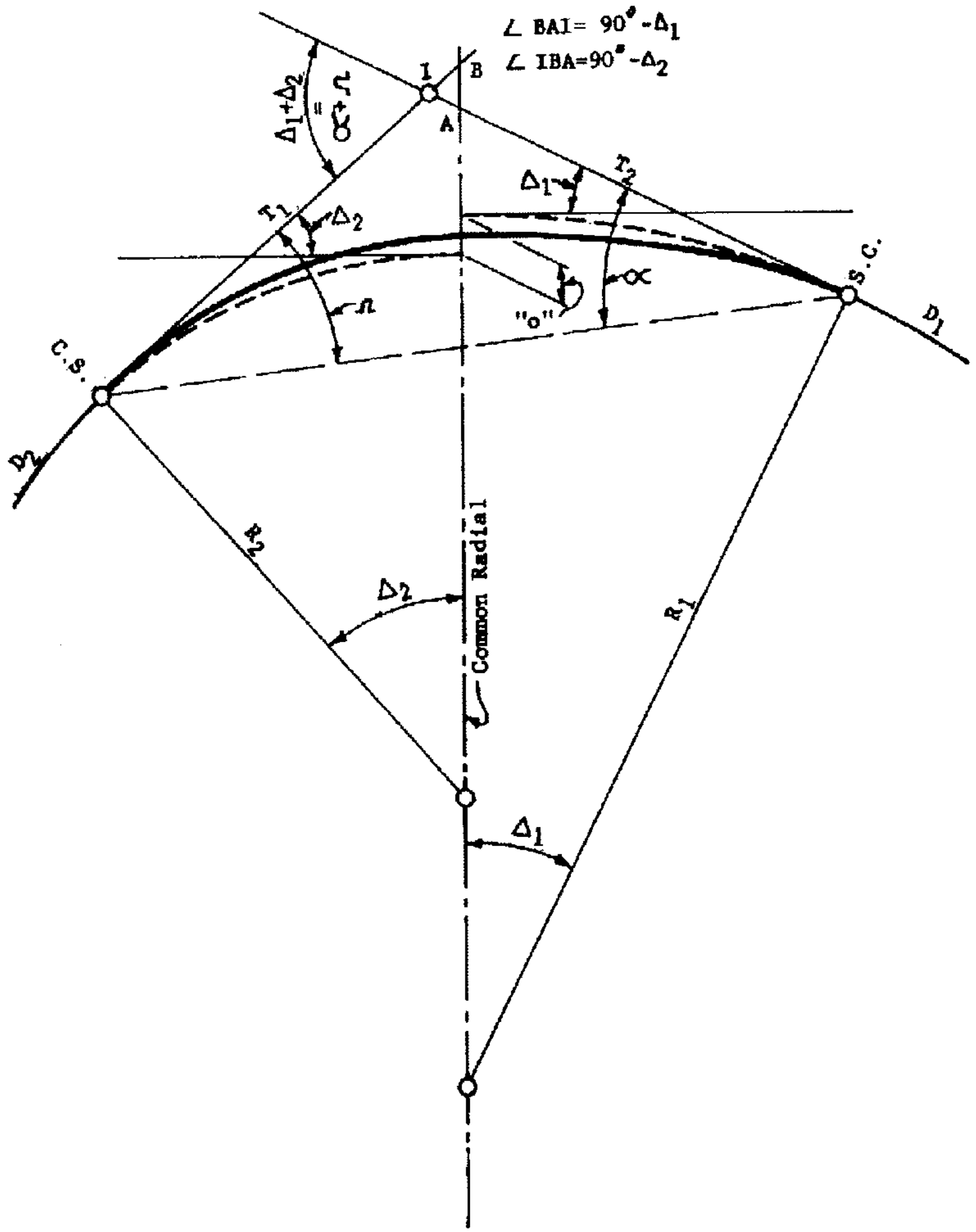


$\alpha = \frac{1}{2}aL_{S2}(L_{S3}-L_{S2}) + 1/6a(L_{S3}-L_{S2})^2$

$\Omega = \frac{1}{2}aL_{S2}(L_{S2}-L_{S1}) - 1/6a(L_{S2}-L_{S1})^2$

DEFLECTION ANGLE FORMULAE FOR SET-UP AT POINT ON SPIRAL

DESIGN APPROVED / APPROVED FOR DISTRIBUTION	STATE OF ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAYS DIVISION PLANS GUIDE	REV. DATE 1/32
	FULL TRANSITION SPIRAL	PLAN NO. D-55.10



Intermediate Spiral Transition is basically the same as Partial Transition Spiral illustrated by Drwg. No D-55.20.

Select L_s and a from Drwg. No. D-56.10 through Drwg. No. D-56.30 for design speed and $D=D_1-D_2$. These values are applied throughout the following formulae.

L_s (sta.) $=(D_2-D_1)/a$

a(degrees) $=(D_2-D_1)L_s$

D_p (sta.) = Degree of curvature at any point on spiral.
= $D_2-(a)$(distance in sta. from C.S. to point).
= $D_1+(a)$(distance in sta. from S.C. to point).

"o" (ft.) $=0.0727(D_2-D_1)\left(\frac{D_2-D_1}{a}\right)^2$

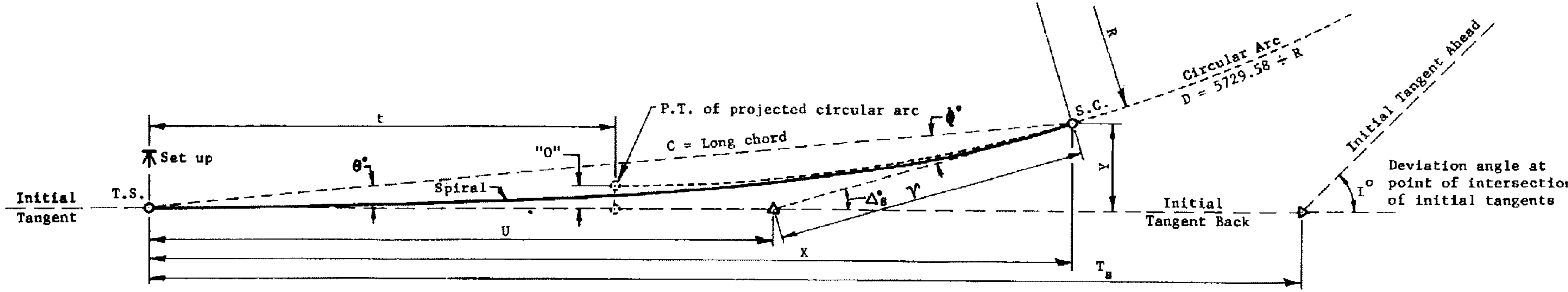
Ω (degrees) $=1/2\ D_2\left(\frac{D_2-D_1}{a}\right)-1/6\ a\left(\frac{D_2-D_1}{a}\right)^2$

α (degrees) $=1/2\ D_1\left(\frac{D_2-D_1}{a}\right)+1/6a\left(\frac{D_2-D_1}{a}\right)^2$

To calculate deflections and spiral distance to any point on spiral, substitute D_p for D_1 or D_2

Δ_1 = (degrees) $=D_1(L_s/2)$
Δ_2 = (degrees) $=D_2(L_s/2)$
$AB=R_2$ in feet (exsec. Δ_2) $-R_1$ in feet (exsec. Δ_1) $-$"O"
AI (ft.) $=AB\left[\frac{\cos\Delta_2}{\sin(\Delta_1+\Delta_2)}\right]$
BI (ft.) $=AB\left[\frac{\cos\Delta_1}{\sin(\Delta_1+\Delta_2)}\right]$
T_1 (ft.) $=R_1$ in feet $(\tan\Delta_1)$ + AI
T_2 (ft.) $=R_2$ in feet $(\tan\Delta_2)$ - BI

DESIGN APPROVED	STATE OF ARIZONA DEPARTMENT OF TRANSPORTATION HIGHWAYS DIVISION PLANS GUIDE	REV DATE 1/82
APPROVED FOR DISTRIBUTION	SPIRAL TRANSITION COMPOUND CURVES	PLAN NO. D-55.30



L_s	D	R	"O"	t	Δ°_s	θ°	ϕ°	γ	U	C	X	Y
00	00-00-00	C0.00	0.00	0.00	00-00-00	00-00-00	00-00-00	0.00	0.00	0.00	0.00	0.00
25	0-15- 0	22918.31	0.00	12.50	0- 1-53	0- 0-38	0- 1-15	8.33	16.67	25.00	25.00	0.00
5C	0-30- 0	11459.16	0.01	25.00	0- 7-30	0- 2-30	0- 5- 0	16.67	33.33	50.00	50.C0	0.04
75	0-45- 0	7639.44	0.03	37.50	0-16-53	0- 5-38	0-11-15	25.00	50.00	75.00	75.00	0.12
100	1- 0- 0	5729.58	0.07	50.0C	0-30- 0	0-10- 0	0-20- 0	33.33	66.67	100.00	100.00	0.29
125	1-15- 0	4583.66	0.14	62.50	0-46-53	0-15-38	0-31-15	41.67	83.33	125.00	125.00	0.57
150	1-30- 0	3819.72	0.25	75.00	1- 7-30	0-22-3C	0-45- 0	50.0C	100.00	150.00	149.99	0.98
175	1-45- 0	3274.04	0.39	87.50	1-31-53	0-30-38	1- 1-15	58.34	116.67	174.99	174.99	1.56
200	2- 0- 0	2864.79	0.58	1C0.00	2- 0- 0	0-40- 0	1-20- 0	66.68	133.34	199.99	199.98	2.33
225	2-15- 0	2546.48	0.83	112.49	2-31-53	0-50-38	1-41-15	75.02	150.01	224.98	224.96	3.31
250	2-30- 0	2291.83	1.14	124.99	3- 7-30	1- 2-30	2- 5- 0	83.36	166.69	249.97	249.93	4.54
275	2-45- 0	2083.48	1.51	137.48	3-46-53	1-15-38	2-31-15	91.71	183.37	274.95	274.88	6.05
3C0	3- 0- 0	1909.86	1.96	149.97	4-30- 0	1-30- 0	3- 0- 0	100.06	200.06	299.92	299.81	7.85
325	3-15- 0	1762.95	2.50	162.45	5-16-53	1-45-38	3-31-15	108.43	216.76	324.88	324.72	9.98
350	3-30- 0	1637.02	3.12	174.93	6- 7-30	2- 2-30	4- 5- 0	116.80	233.46	349.82	349.60	12.46
375	3-45- 0	1527.89	3.83	187.41	7- 1-53	2-20-38	4-41-15	125.20	250.18	374.75	374.43	15.33
400	4- 0- 0	1432.39	4.65	199.87	8- 0- 0	2-40- 0	5-20- 0	133.60	266.92	399.65	399.22	18.59
425	4-15- 0	1348.14	5.58	212.32	9- 1-53	3- 0-38	6- 1-15	142.03	283.67	424.53	423.94	22.30

GENERAL NOTES

For definitions of spiral values and their applicable formulae, see Std. D-55.10.

For deflection angle formulae for an instrument set-up at a point on spiral, see Std. D-55.10.

For partial transition spiral formulae, see Std. D-55.20.

For spiral transition between compound curves, see Std. D-55.30.

For curvature, superelevation and superelevation transition standards, see Std. D-56.10, D-56.20 and D-56.30.

For superelevation distribution, see Std. D-56.40.

DESIGN APPROVED

APPROVED FOR DISTRIBUTION

STATE OF ARIZONA
DEPARTMENT OF TRANSPORTATION
HIGHWAYS DIVISION
PLANS GUIDE

REV. DATE 1/82

TRANSITION SPIRAL TABLE FOR a=1

PLAN NO. D-57.22

RESULTS OF SURVEY

DATA TABLE		
5	S03°03'49"W	800.28'
6	S89°52'06"E	368.83'

LEGEND

- 302 Set Monument
- 300 Found Monument
- 301 Calculated position
- Existing ADOT R/W monument
- SFNF Seacherd For Not Found

CHANGE ORDER REVISIONS			
C.O. NO.	DATE	BY	DESCRIPTION OF REVISIONS

DRAWING NO.	D-03-T-694
SURVEY	Aug 2008
DRAWN/DATE	Jordan/Nov 08
ADOT REVIEW	Ken Richmond

HUBBARD ENGINEERING 480-892-3313 Gilbert, AZ jcrume@heaz.us Job # 08121

ARIZONA DEPARTMENT OF TRANSPORTATION
INTERMODAL TRANSPORTATION DIVISION
RIGHT OF WAY PLANS SECTION

HIGHWAY NAME: WILLIAMS-GRAND CANYON-CAMERON

FEDERAL AID NO.: UNASSIGNED

PROJECT NO.: 064 CN 185 H7142 01R

ROUTE NO.: S.R. 64

LOCATION: Jct. I-40 - Tusayan

PRELIMINARY NOT FOR CONSTRUCTION OR RECORDING
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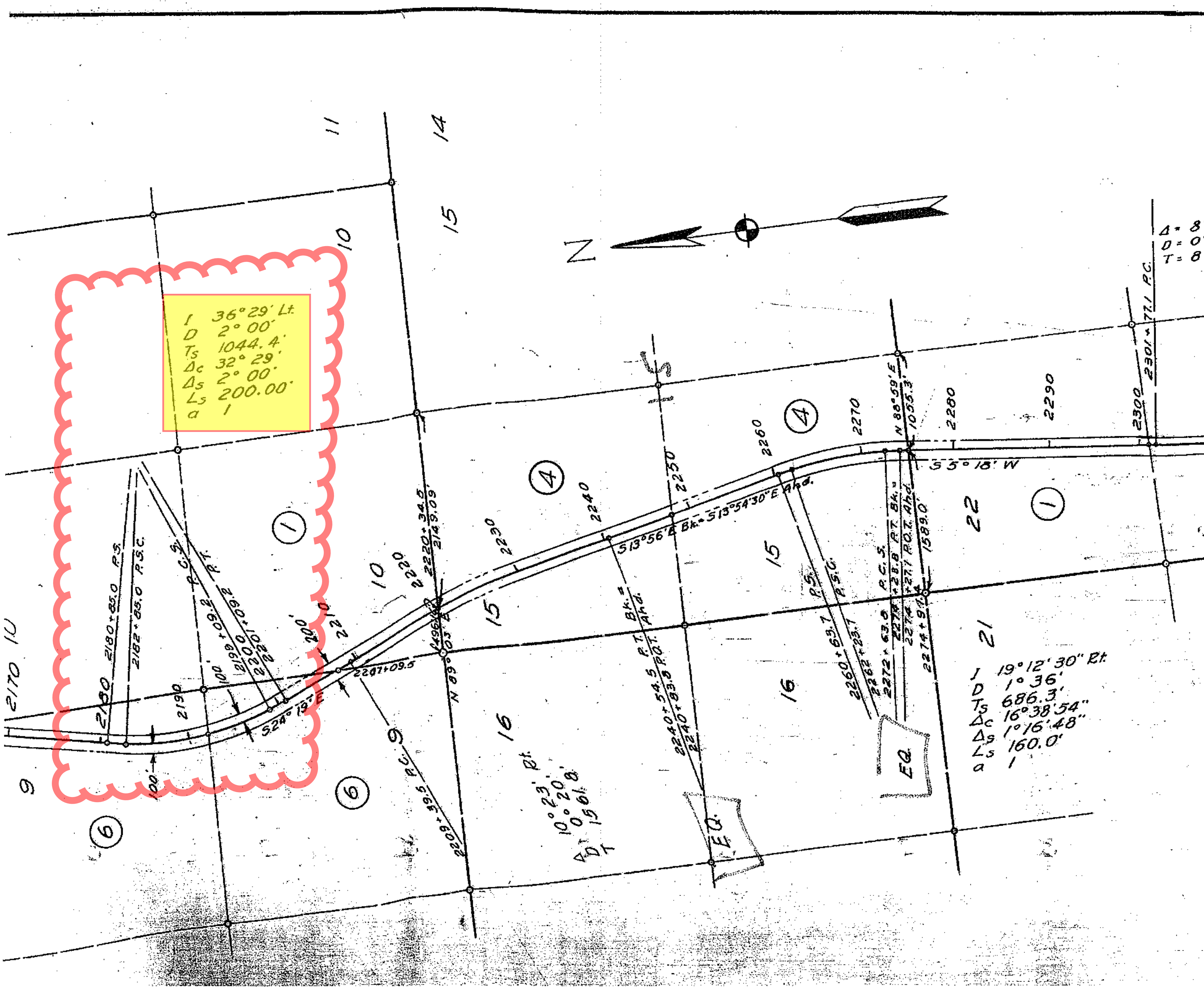
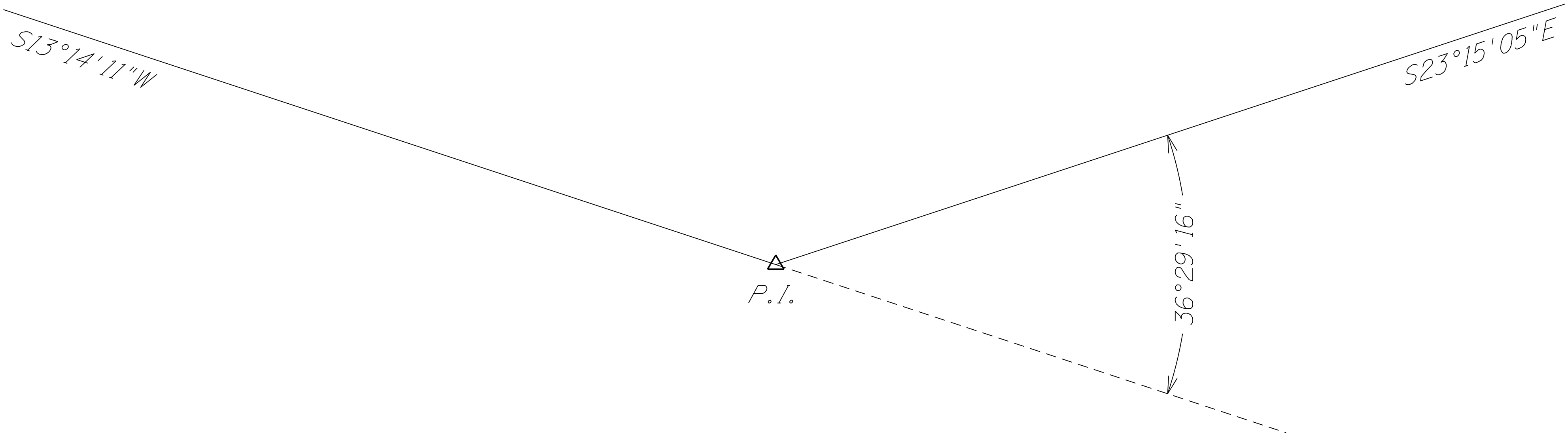
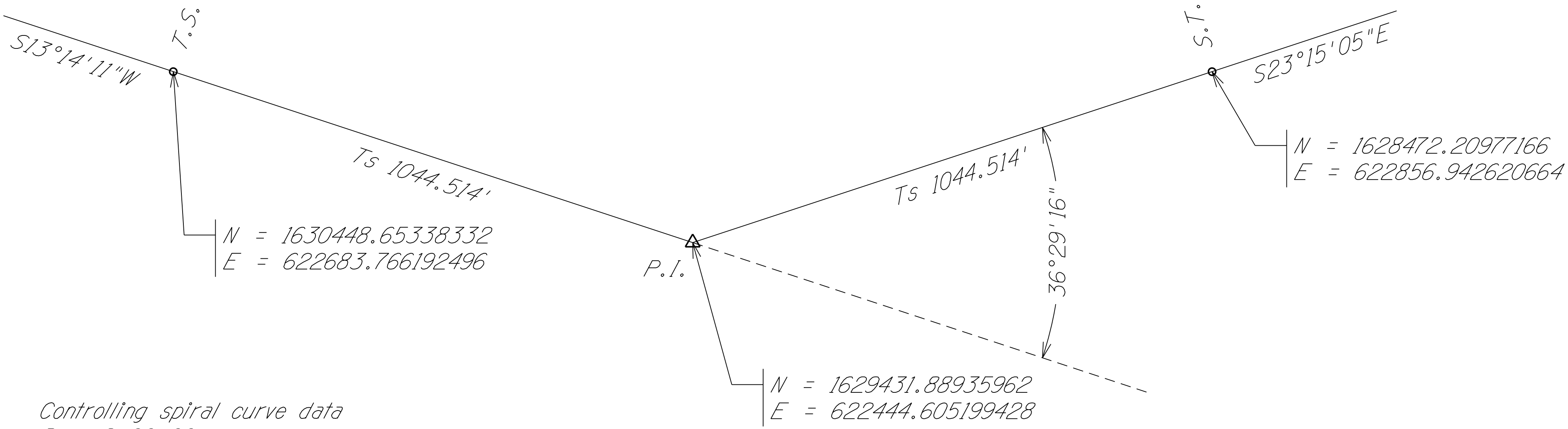
SHEET RS-17



NO.	N
1	State of
2	Ariz. Lives
3	Dr. R.O.
4	Howard
5	Joaquin
6	J. M. Pe
7	J. A. Ho
8	State of (Highw



Controlling spiral curve data
D = 2-00-00
Ls = 200.00'



Controlling spiral curve data
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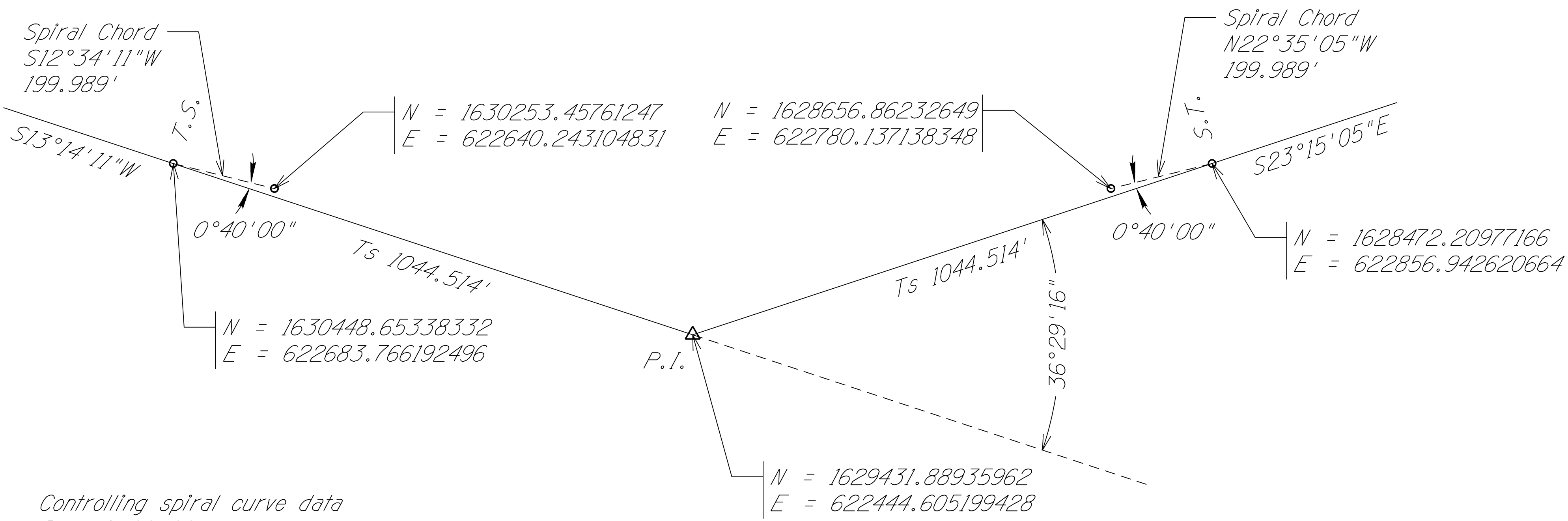
Ls = 200.00'



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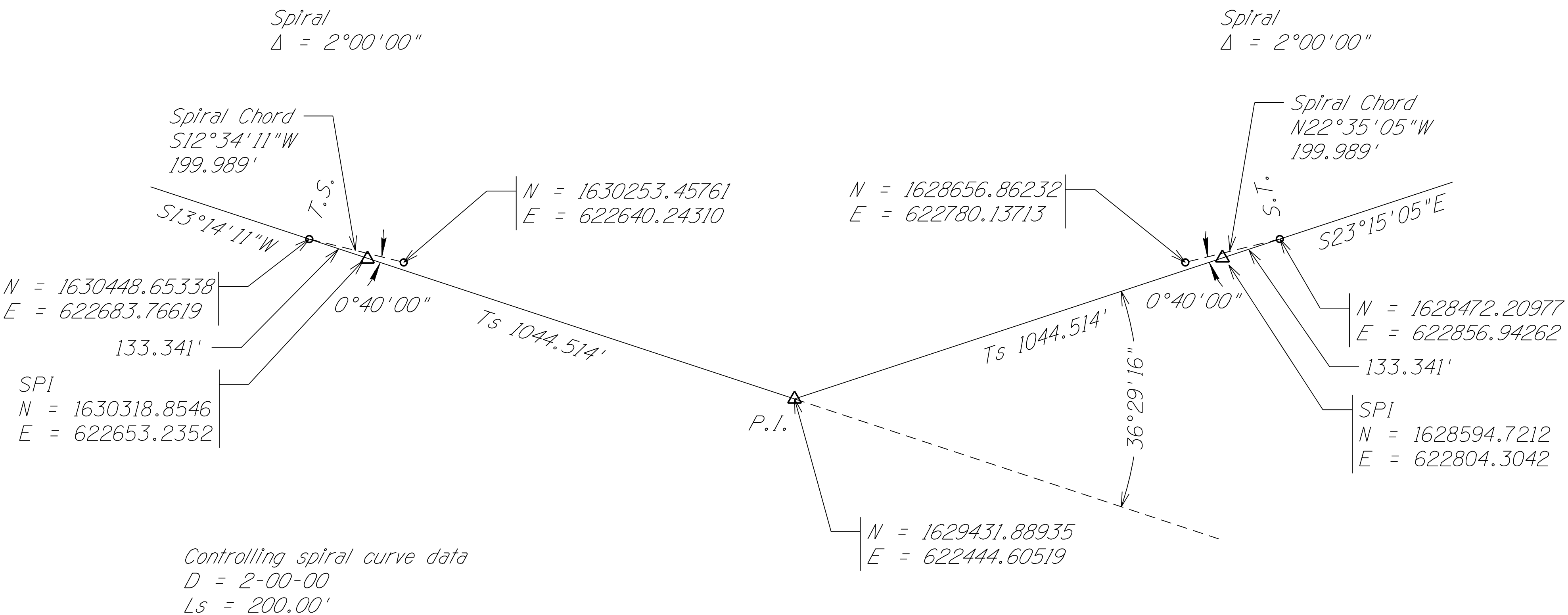
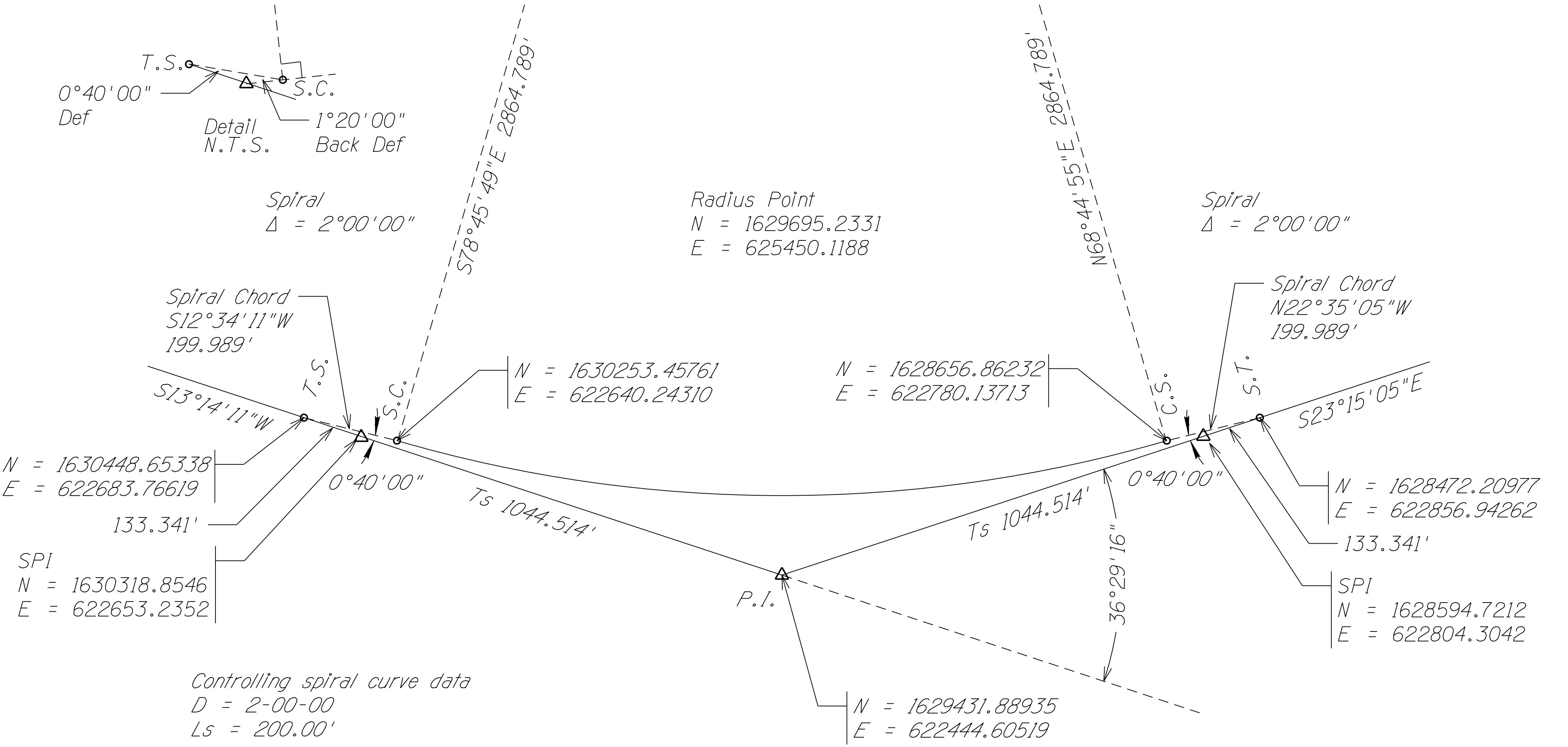
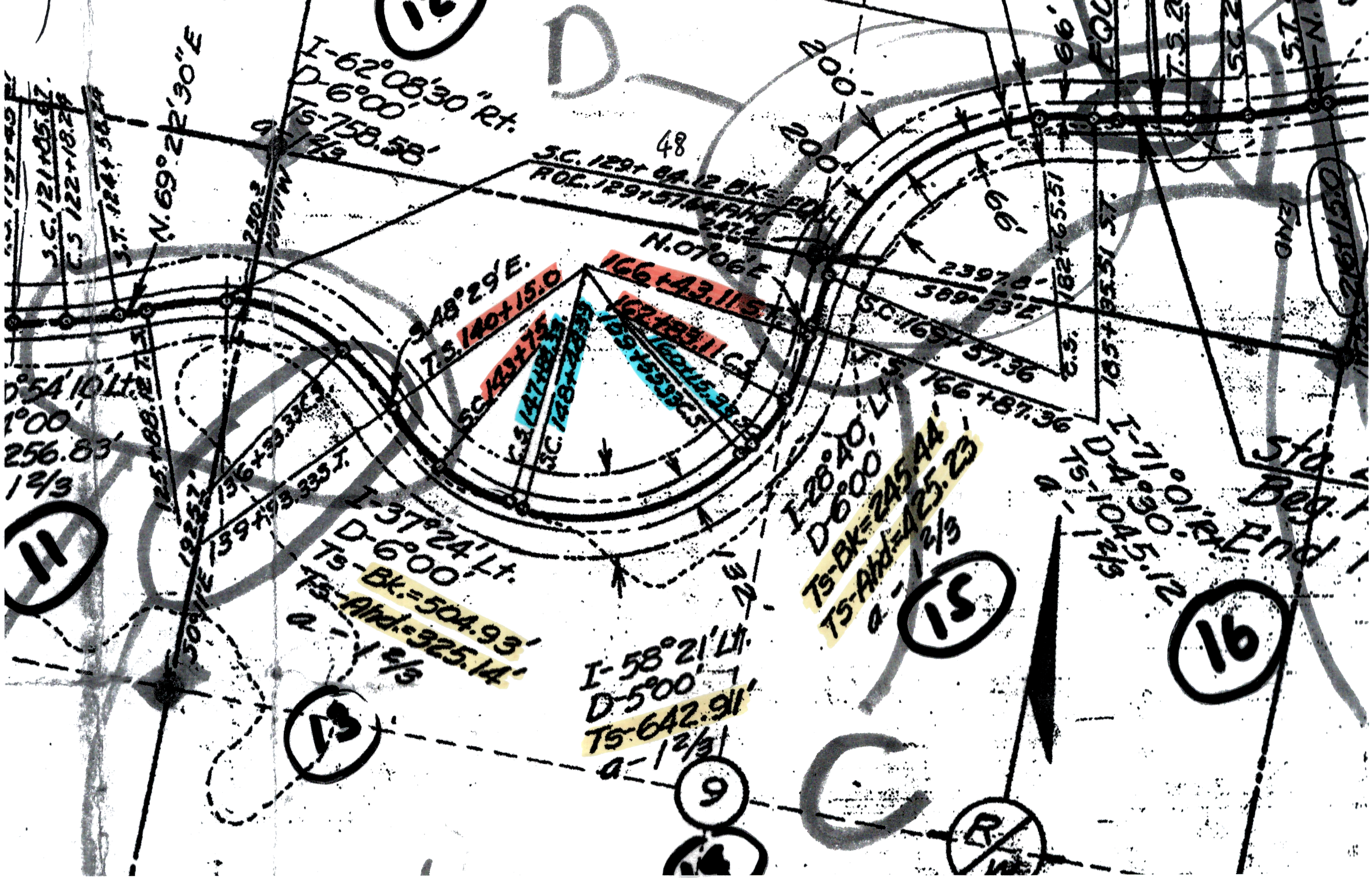


Spiral
Δ = 2°00'00"
Spiral Chord
S12°34'11"W
199.989'
T.S.
S13°14'11"W
N = 1630253.45761
E = 622640.24310
N = 1630448.65338
E = 622683.76619
0°40'00"
133.341'
SPI
N = 1630318.8546
E = 622653.2352
Ts 1044.514'
P.I.
N = 1629431.88935
E = 622444.60519
Spiral
Δ = 2°00'00"
Spiral Chord
N22°35'05"W
199.989'
N = 1628656.86232
E = 622780.13713
S.T.
S23°15'05"E
0°40'00"
Ts 1044.514'
36°29'16"
N = 1628472.20977
E = 622856.94262
133.341'
SPI
N = 1628594.7212
E = 622804.3042
Controlling spiral curve data
D = 2-00-00
Ls = 200.00'


T.S.
S.C.
0°40'00"
Def
Detail
N.T.S.
1°20'00"
Back Def
S78°45'49"E 2864.789'
N68°44'55"E 2864.789'
Spiral
Δ = 2°00'00"
Radius Point
N = 1629695.2331
E = 625450.1188
Spiral
Δ = 2°00'00"
Spiral Chord
S12°34'11"W
199.989'
Spiral Chord
N22°35'05"W
199.989'
T.S.
S.C.
N = 1630253.45761
E = 622640.24310
N = 1628656.86232
E = 622780.13713
C.S.
S.T.
S13°14'11"W
S23°15'05"E
N = 1630448.65338
E = 622683.76619
0°40'00"
0°40'00"
N = 1628472.20977
E = 622856.94262
133.341'
Ts 1044.514'
Ts 1044.514'
133.341'
36°29'16"
SPI
N = 1630318.8546
E = 622653.2352
P.I.
SPI
N = 1628594.7212
E = 622804.3042
Controlling spiral curve data
D = 2-00-00
Ls = 200.00'
N = 1629431.88935
E = 622444.60519



D
48
I-62°08'30"Rt.
D-6°00'
Ts-758.58'
N.69°22'30"E
N.07°06'E
S.48°29'E.
T.S. 140+15.0
S.C. 143+75
166+43.11 S.T.
200'
66'
2397.8'
S89°53'E
S.C. 169+37.36
T.S. 166+87.36
I-37°24'Lt.
D-6°00'
Ts-Bk.=504.93'
Ts-Ahd.=925.14'
I-58°21'Lt.
D-5°00'
Ts-642.91'
I-28°40'Lt.
D-6°00'
Ts-Bk=245.44'
Ts-Ahd=425.23
I-71°01'Rt.
D-4°30'
Ts-1045.12
11
13
15
16
9
C

1435
1444
1335
ST 166+43.12
1340
1430
1338
26°52'12.5"
10°48'11.4"
1332
124°25'00.0"
a=1 2/3
Ls=360.00'
Δ=10°48'00"
TS=424.23' AHD
1429
35°35'48.4"
55°21'00.0"
16°04'01.1"
CS 162+83.12
1339
15
10°47'47.5"
SC 160+15.
1251
24°48'00.9"
03°18'00.0"
CS 159+55.34
TS 140+15.00
L.T.B. (in): N 34-24-16 E
D.O.C. Arc: 6-00-00
Radius: 954.93
Delta Angle: 16-04-01 (LT)
Tangent length: 134.78
Arc length: 267.78
L.T.B. (out): N 18-20-15 E
TS=245.44' BK
1337
Transitional Spiral
(Table D-55.30)
a=1 2/3
Ls=60.00'
Δ=3°18'00"
1935
03°17'59.1"
1336
SC 143+75.00
14
1428
1330
1423
a=1 2/3
Ls=360.00'
Δ=10°48'00"
CS 147+88.34
SC 148+48.34
13
TS=642.91'
TS=504.93' BK
1426
Transitional Spiral
(Table D-55.30)
a=1 2/3
Ls=60.00'
Δ=3°18'00"
1331
1427
L.T.B. (in): S 86-56-44 E
D.O.C. Arc: 5-00-00
Radius: 1145.92
Delta Angle: 55-21-00 (LT)
Tangent length: 600.98
Arc length: 1107.00
L.T.B. (out): N 37-42-16 E
TS=325.14' AHD
1249
1333
1334
TS=642.91'
1934
1250
L.T.B. (in): S 58-50-44 E
D.O.C. Arc: 6-00-00
Radius: 954.93
Delta Angle: 24-48-01 (LT)
Tangent length: 209.96
Arc length: 413.34
L.T.B. (out): S 83-38-45 E

RESULTS OF SURVEY

** RECORD DIST: ANNOTATION PER STRIP MAP 4-T-137

*** TRANSITIONAL SPIRAL CALCULATED USING FORMULAS AND RELATIONSHIPS SHOWN ON PLAN NO. 55.30, REVISED DATE OF 1/82, OF 1986 ADOT ROADWAY GUIDES FOR USE IN OFFICE AND FIELD.

* DENOTES A U.S.F.S. SPECIAL USE PERMIT DATED 6-22-49 WHICH INCLUDES A 132' RIGHT OF WAY WHEREIN THE ROAD WILL BE PARAMOUNT, BUT, NO USE OR OCCUPANCY OTHER THAN FOR CONSTRUCTION AND MAINTENANCE OF THE ROAD IS AUTHORIZED WITHOUT PERMIT FROM THE FOREST SERVICE, AND A 132' WIDE PERMIT TO CONSTRUCT AND MAINTAIN A FENCE. WHERE THE FENCES ARE CONSTRUCTED OUTSIDE OF THE 132' RIGHT OF WAY, NO IMPROVEMENTS OTHER THAN THE FENCES SHALL BE CONSTRUCTED BY THE STATE EXCEPT BY AGREEMENT WITH THE FOREST SUPERVISOR. A 400' WIDE SCENIC STRIP OF "SET BACK" WHEREIN NO CONSTRUCTION OTHER THAN THAT NECESSARY TO THE CONSTRUCTION OF THE HIGHWAY WILL BE ALLOWED, EXCEPT BY SPECIAL PERMIT FROM THE FOREST SERVICE.

LEGEND

- 302 Set Monument
- 300 Found Monument
- 301 Calculated position
- Existing R/W monument

CHANGE ORDER REVISIONS

C.O. NO.	DATE	BY	DESCRIPTION OF REVISIONS

DRAWING NO.	D-04-T-432
SURVEY	April 2006
DRAWN/DATE	J Crume/2006
ADOT REVIEW	C. Woodford
ROUTE NO.:	U.S. 60

HUBBARD ENGINEERING 480-892-3313 Gilbert, AZ jcrume@heaz.us Job # 26015

ARIZONA DEPARTMENT OF TRANSPORTATION
INTERMODAL TRANSPORTATION DIVISION
RIGHT OF WAY PLANS SECTION

HIGHWAY NAME: PHOENIX - GLOBE

FEDERAL AID NO.: Unassigned

PROJECT NO.: 060 GI 236 H6140 01R

LOCATION: County Line - Pinto Valley

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SHEET RS-8