Transition curves, also known as spiral curves, were used on Interstate Highways, County Roads and Railroads. Most of the public right of ways have been re-platted to eliminate the spirals on right of way but there still are a few to give the Land Surveyor a challenge.

This proposed solution deals with a railroad right of way in Rogers, Minnesota. The example was chosen because our survey involved two different plats and a boundary survey prepared by others. The spiral curve was either ignored or dealt with incorrectly. The tables used for the data are for highway spirals but the application is close enough to give a valid boundary for the survey. If data tables could be found that applied to railroad curves, the calculations and path to the solution would be very similar. The tables, formulas and calculations are from the book “Transition Curves for Highways” by the Federal Works Agency, published in 1940. Copies are available through Amazon.com for a very reasonable price.
A normal spiral curve consists of three basic parts; the beginning spiral, a central circular curve and ending spiral. Whether working with a highway or a railroad, the right of way map or centerline description is needed. The minimum data necessary is the degree of curve, central angle of the circular curve, length of spiral and spiral central angle. From field measurements and a few calculations the spiral can be positioned.
Locate the center of track from about 500 feet before the curves to 500 feet beyond the curves. A shot every 50 feet through the curves will help to test the theoretical solution to the actual location of the tracks. Location of all found monuments and other physical objects should be included in the survey.

Calculated data needed to set up the curves include the central circular curve radius, circular curve central angle, circular curve tangent, spiral long tangent and spiral short tangents. See the typical curve drawing in the attached data.
My assumption is that most surveyors will use cad software for the calculations. The solution can be tested manually. The method is in the above-mentioned book.

Use the field data to establish a best fit of the tangents running into and out of the curves. Intersect the tangents to determine P.I. of the curve set.

Determine the overall central angle for the curve set. The overall central angle will rarely match the plan angle. Adjust the difference in the circular curve and hold the spiral curve angles to the map or description angles.

Overall Central Angle
- Spiral Angle
Circular Central Angle

17 d 26’ 06”
-04 d 09’ 36”
09 d 06’ 54”
This application is for a rail line so the chord definition is used to calculate the radius of the circular curve.

\[ \text{Radius} = \frac{50}{\sin(2 \, 08')/2} = 2685.89 \]

Calculate the Tangent for the circular curve.

\[ \text{Tangent} = 2685.89 \times \tan(09 \, 06'54'')/2 = 214.11 \]

All highway spirals are referred to as 10 chord spirals. The length is always a multiple of 50 feet. Railroad spirals do not hold to the length rule so their needs to be some interpolation of the tables to achieve a reasonable solution.

Use the tables to determine the Long Tangent and Short Tangent for a 390 foot spiral. Use the data for a 2d 00’ curve or interpolate if the variation is large enough to make a difference.
Off to the side in the cad software, use the tangent data and central angles to set up the curve tangents. Move the tangents onto the drawing, matching lines of the track centerline.

Extend radial lines to the right of way for the Begin Spiral, Spiral Circular point (SC), Circular Spiral point (CS) and Spiral Tangent (ST).
Construct the spiral on centerline using cad.

Curves and Lines
Create Spirals
Fit Tangent to Curve
Select Tangent
Select Curve

Zoom into the centerline to test the physical location of the tracks relative to the calculated curves. The expectation is that the mathematical solution should be within a few tenths of a foot of the actual location of the tracts. If there is a greater divergence, then the curves should be adjusted for a better fit.

Offset the Circular Curve to set the right of way.

There are two ways to establish the spiral curve on the right of way. The first, is to simply offset it the same as the circular curve. It’s a reasonable solution and width checks through the curve indicate that is a parallel spiral. If the curve is measured using cad inquiry, the data returned is the same as centerline.
The second solution, is to use the method outlined above for the spiral on a centerline. The solution will give a different curve than the offset method and the width will also check properly. There will be some variation in the locations of the TS, SC, CS and ST. These positions can be adjusted by trimming and extending the curves to the original positions established by extending the radial lines. It is a good idea to calculate areas before trimming and adjusting the locations of the TS, SC, CS and ST.

The spiral curve data to be shown for the survey or plat should be the chord and chord bearing. The chord bearing and chord length can be measured directly from the location of the TS and SC. The Spiral Length is determined from the Table II - Functions of Transitions.
Spiral Central 4.1 d = LC 0.99977
Spiral Length = Chord / LC = 389.91/0.99977 = 390.00

Overall Spiral curve lengths on the right of way can be determined using the same equation. Arc lengths of sub-portions of spirals can’t be determined using this method. For sub-portions of the spiral, show the Chord and Chord Bearing.

Calculating an area can be a problem with cad once the curves have been adjusted. There may be enough of a gap at the curve ends to cause the software to fail. A solution is to draw and use the chords to measure the area. There may need to be an adjustment for the area between the arc and chord.