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Maine Department of Transportation

Transportation Research Division

Technical Report 02-3

The use of Micro-Surfacing for Pavement Preservation

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Introduction

The Maine Department of Transportation (MDOT) is responsible for maintaining approximately 14,000 kilometers of public highways. Maintenance of these highways consists of rehabilitation or reconstruction when the road has deteriorated to an unacceptable level. With economic fluctuations and ever increasing traffic levels, this policy does not effectively address the needs of the highway system when maintenance is necessary and creates a backlog of deficient highways.

To reduce this trend, many states have adopted the policy of Pavement Preservation. This policy consists of applying preventative maintenance to the roadway before it has deteriorated to an undesirable level, maintaining the structural integrity and extending the service life of the pavement. Length of time between costly rehabilitation is increased, reducing the cost of maintaining the highway system. Several states have reported that they were able to improve the overall condition of their highway system after trying this approach and that every dollar spent using preventative maintenance could save up to six dollars in future spending.

Maine has two types of roads: “A” roads, which are built to state standards and “B” roads, which are not. Pavement Preventive Maintenance (PPM) can be used effectively on “A” roads to extend service life.

Examples of PPM treatments include Crack Sealing, Thin Overlays, and Micro-Surfacing. Crack Sealing prevents water and debris from entering cracks in the pavement by sealing them with a rubberized material. Hot Maintenance Mulch is a hot mix asphalt pavement with little or no crushed aggregate and is typically used on “B” roads. Thin Overlays are dense - open graded Superpave mixes including recycled mixes that are typically used on “A” roads. Micro-Surfacing is a thin overlay of a mixture of polymer-modified asphalt emulsion, mineral aggregate, mineral filler, and water.

This report will examine the application of Micro-Surfacing to extend the service life of two projects in Aroostook County.

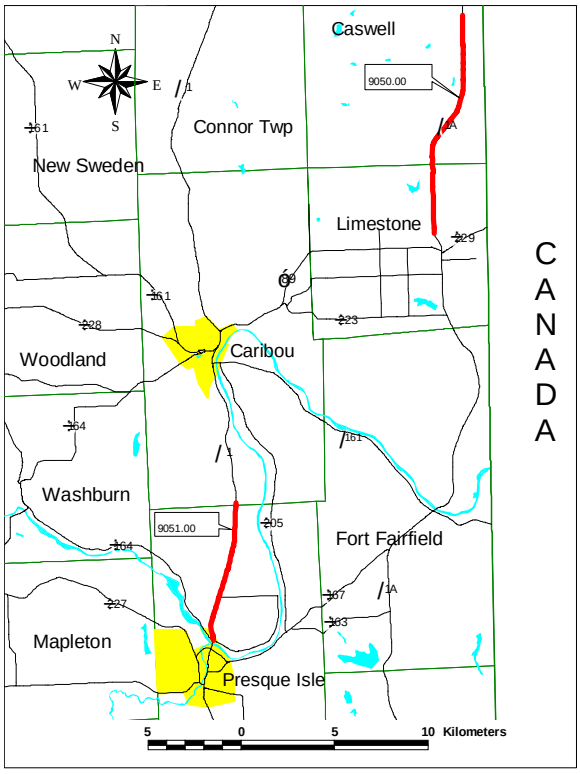
Scope

Project Identification Number (PIN) 9051.00 is located on Route 1 between the cities of Presque Isle and Caribou and PIN 9050.00 is on Route 1A between Limestone and Caswell. Each project will be resurfaced with Hot Mix Asphalt Overlay and Micro-Surfacing. Both projects will have Test and Control Sections to evaluate and monitor frictional resistance, reflective cracking, rutting, and roughness.

Preliminary Data Collection

Project Location

PIN 9051.00 begins at station 10+000 and ends at 18+514. This project has two sections of Micro-Surfacing, one between stations 11+225 and 13+500 and another between 16+780 and 18+514. A Level 2 Overlay, comprised of a minimum depth of 13 mm of 9.5 mm Hot Mix Asphalt (HMA) Shim topped with 30 mm of 9.5 mm HMA Surface, will be placed on the remaining sections. To evaluate each treatment, two 100-meter test and two 100-meter control sections were established. Micro-Surfaced test sections begin at station 13+300 (Section 1) and 16+880 (Section 4). Control sections begin at station 13+600 (Section 2) and 16+580 (Section 3).



Project limits for PIN 9050.00 are from station 9+990 to 23+600. Micro-Surfacing was placed between stations 9+990 and 16+000. A Level 2 Overlay with a minimum depth of 15 mm of 9.5 mm HMA shim and 30 mm of 9.5 mm HMA surface mix was placed between stations 16+000 and 23+600. One 100-meter test and one 100-meter control section were established. The Micro-Surfaced test section begins at station 15+800 (Section 5) and the control section begins at station 16+100 (Section 6).

Crack Analysis

To monitor reflective cracking, crack patterns of each section were documented prior to paving and are displayed in Figures 1 - 6.

All sections have transverse cracks and longitudinal cracking at the shoulder joints. Sections 2, 3, and 5 have longitudinal cracking in the wheel path.

Roughness and Rut Depth

Roughness and rut depths were measured using the Automatic Road Analyzer (ARAN) and will be summarized later in the report.

Mix Design

Mix Designs from Micro-Surfacing projects in Canada and a report titled “Recommended Performance Guidelines for Micro-Surfacing” by the International Slurry Surfacing Association (ISSA) were reviewed

to aid in the development of a mix design. Materials used in Micro-Surfacing include mineral filler, binder, aggregate, and water.

Mineral Filler

Non-air entrained Portland cement was used as mineral filler.

Binder

The binder is a quick set polymer modified cationic type CSS-1H emulsion or approved equivalent that shall conform to the following requirements.

Test	Property	Requirements
ASTM D244	Residue by Distillation % by Mass (Test Temperature should be less than 138º C)	62 % minimum

Tests on Residue		
ASTM D36	Softening Point	57º C minimum
ASTM D5	Penetration at (25º C, 100 g, 5s) 0.1 mm	40 - 90
ASTM D2170	Kinematic Viscosity at 135º C	650 mm² /s minimum

Aggregate

Aggregate shall consist of 100% crushed bedrock material and shall conform to the following gradation and test requirements.

ASTM Sieve Size	Percent Passing	Tolerance Levels
9.5 mm	100	± 5 %
4.75 mm	70 - 90	± 5 %
2.36 mm	45 - 70	± 5 %
1.18 mm	28 - 50	± 5 %
600 um	19 - 34	± 5 %
300 um	12 - 25	± 4 %
150 um	7 - 18	± 3 %
75 um	5 - 15	± 2 %

Test	Property	Requirements
AASHTO TP 58-99	Micro Deval	16.0 or less

Mix Properties

All component materials used in the mix design shall conform to the following requirements.

Test	Property	Requirements
ISSA TB-139	Wet Cohesion @ 30 minutes minimum (set) @ 60 minutes minimum (traffic)	12 kg-cm minimum 20 kg-cm minimum
ISSA TB-109	Excess Asphalt by LWT Sand Adhesion	538 g/m² maximum
ISSA TB-114	Wet Stripping	Pass (90 % minimum)
ISSA TB-100	Wet Track Abrasion Loss One Hour Soak Six Day Soak	538 g/m² maximum 807 g/m² maximum
ISSA TB-147A	Lateral Displacement Specific Gravity after 1000 cycles of 57 kg	5 % maximum 2.10 maximum
ISSA TB-144	Classification Compatibility (AAA, BAA)	11 grade points minimum
ISSA TB-113	Mix Time at 25º C	Controllable to 120 s minimum

Job Mix Formula

McAsphalt Engineering Services of Scarborough, Ontario analyzed trial batches of Micro-Surface mix to develop a job mix formula. The following table contains results of that analysis.

Design	**1**	**2**	**3**	
% Aggregate	100	100	100	
% Filler	1.0	1.0	1.0	
% Water	10.0	9.0	7.0	
% Binder	10.0	13.0	16.0	
Analysis				**ISSA Spec**
Appearance	Dry	Medium Rich	Rich	
Texture	Rough	Smooth	Smooth	
Mixing Time	120+	150+	180+	>180 sec
Cohesion @ 30 min kg-cm	16	24	30	12.0 min
Cohesion @ 30 min kg-cm	31.0	32.0	35.0	20.0 min
Wet Track Abrasion Test g/m² 1 Hr	859.0	335.8	263.7	538 g/m² max
Wet Track Abrasion Test g/m² 6 Day	1028.0	539.3	356.3	807 g/m² max
Wet Stripping %	96.0	96.0	96	90 % min
Lateral Displacement %	3.3737	2.139	1.562	5 % max
Excess Asphalt by Loaded Wheel	575.3	410.2	360.3	538 g/m² max
Classification Compatibility Test		BAA	11	11 Pts min

The recommended Micro-Surfacing design is as follows:

Aggregate	100 %
Portland Cement	1.0 %
Water	10.0 %
Binder	12.0 % ± 1%

This design recommendation meets the following specification:

Test	Result	ISSA Spec
Residual Asphalt	8.3	5.5 - 9.5
Wet Track Abrasion - 1 Hr	470.0	538 g/m² max
Wet Track Abrasion - 6 day	680.0	807 g/m² max
Excess Asphalt Loaded Wheel	453.2	538 g/m² max
Wet Stripping	96.0	90 min
Compatibility	BAA - 11 pts	BAA, AAA, 11, 12

Once production begins in the field, adjustments to the mix may have to be made.

Construction

Equipment

Industrial Cold Milling Ltd. of Dartmouth, N.S, supplied the specialized equipment to mix and apply Micro-Surfacing. Four pieces of equipment are necessary to Micro-Surface a roadway: material supply truck, paver, rut box, and hydraulic spreader box.

Material Supply Truck

This unit is positioned ahead of the paving unit and supplies aggregate, emulsion, and water to the paver by way of hoses for the liquid materials and a chain driven belt for the aggregate.

This unit is capable of supplying 8.5 m^3 (11 yd^3) of aggregate, 2000 L (530 gal) of emulsion and 2000 L (530 gal) of water.

Paver

The paving unit is a Bergkamp Mobile Mix Paver - 1 (MMP-1). This is a self-propelled mixing machine that is capable of moving the supply truck and has the capacity of carrying 2.7 m^3 (3.5 yd^3) of aggregate, 2500 L (675 gal) of water, 3000 L (800 gal) of emulsion, 490 L (130 gal) of additive, and 370 kg (800 lb) of mineral filler. The material supply truck continuously replenishes the liquid tanks and aggregate hopper. The mineral filler bin is manually filled from bags stored on top of the paver. The materials are accurately measured and mixed in the pugmill and outlets into the rut or spreader box at the back of the paver.

Rut Box

The Rut Box is a 1.5 m (5 ft) wide screed designed to fill wheel ruts. This unit is attached to the end of the paver and has two V-shaped screeds that channel the larger sized aggregate to the deepest part of the rut while automatically feathering the edges. A chute at the end of the pugmill supplies the Rut Box with material.

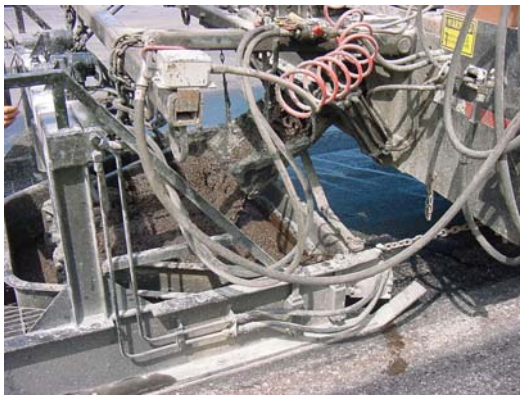
Hydraulic Spreader Box

The Hydraulic Spreader Box is designed to apply the scratch and surface layer. Widths are hydraulically adjusted from 2.4 to 4.3 m (8 to 14 ft) in 15 cm (6-in) increments. The front and rear seal height is adjustable in three places: center and both ends (operator is adjusting the center height in the picture at right). A push bar connecting the box to the paver, controls lateral adjustments. Augers disperse the Micro-Surfacing mix evenly across the box ahead of the front seal as the material is placed on the roadway. A burlap screed attached to each side feathers the longitudinal joint.

Micro-Surfacing

Level 2 Overlay sections on both projects were paved by July of 2001.

Rut-Filling



Micro-Surfacing began on August 8, 2001 for project number 9051.00. The roadway was brushed clean of all debris and a tack coat was applied to the surface.

The rut box, paver and material truck were positioned at station 11+225 at the Level 2 pavement joint. The process starts with blending material in the pugmill then discharging the mix onto a chute, which funnels mix to the rut box. The mixture resembles concrete slurry when discharged. Wheel ruts were filled as the rut box was pulled along the pavement at a rate of 75 m/min (246 ft/min). Angled augers on the rut box direct aggregate to the deepest areas of the rut while feathering the edges to match the existing pavement. Application quantities vary according to rut depth.

The following table illustrates the amount of Micro-Surfacing necessary to level wheel ruts.

Rut Depth	Micro-Surfacing Quantity Per Meter
12.7 - 19.1 mm (0.5 - 0.75 in)	9.1 - 13.6 kg/m² (20 - 30 lb/yd²)
19.1 - 25.4 mm (0.75 - 1.00 in)	11.4 - 15.9 kg/m² (25 - 35 lb/yd²)
25.4 - 31.75 mm (1.00 - 1.25 in)	12.7- 17.3 kg/m² (28 - 38 lb/yd²)
31.75 - 38.1 mm (1.25 - 1.5 in)	14.5 - 18.2 kg/m² (32 - 40 lb/yd²)

Wheel ruts less than 12.7 mm (0.5 in) can be filled using a full width scratch course and ruts in excess of 38.1 mm (1.5 in) may require multiple passes of the rut-filling box.

The Micro-Surfacing mixture is brown in color when freshly placed and turns black as it cures. Water can be seen evaporating from the surface as it cures. Curing rates are dependant on air temperature and relative humidity.

The lane was opened to traffic 1 hour after both wheel ruts were leveled. A twenty-four hour waiting period was recommended before applying the scratch course.

Scratch Course

The Hydraulic Spreader Box is used to place the scratch and surface course. The scratch course is a thin coat of Micro-Surfacing mix used to level the roadway prior to placing the surface course. A stiff rubber strike-off is used to apply only what is necessary to level the roadway. Scratch course application is similar to rut filling with the exception of using the Spreader Box and the application rate is reduced to 37 m/min. Loose aggregate, generated from traffic use on the rut leveling course, was swept off prior to placing the scratch course.

Twin augers are used to agitate and evenly distribute the mixture across the Spreader Box ahead of the front seal. The front seal is height adjustable at the center and on each end. Scratch course layers are very thin requiring very little height adjustments to either the front or the rear seal.

This section of roadway has three lanes. To eliminate rain runoff from pooling at the longitudinal joints, the outside lane is paved first followed by the inside lane with an overlapped joint no greater than 76 mm (3 in) in width.

If the paver should run out of material or a problem develops to disrupt placement, a transverse pavement joint is created by shoveling the loose mix off the roadway before it has time to cure. Micro-Surfacing is resumed at the joint by feathering the mix by hand.

Surface Course

The surface course is placed similarly to the scratch course using the Hydraulic Spreader Box with the addition of a secondary strike-off at the rear of the box to improve surface texture.

Mix proportions are monitored and adjusted using the control box at the rear of the paver.

The same mix design and procedures were used to Micro-Surface project 9050.00 in Limestone.

Both projects were completed by September.

Project Evaluation

The overall appearance of Micro-Surfacing resembles an open-graded mix with exposed stone as the wearing surface. Improvements in ride, rut depth, and frictional resistance are apparent. Pre and post construction test results will be discussed individually.

International Roughness Index

The following table contains International Roughness Index (IRI) tests prior to and shortly after resurfacing.

PIN 9051.00 Presque Isle - Caribou IRI (m/km)		
Test Section	5/7/2001	10/31/2001
1 (Micro-Surfacing)	0.97	0.93
2 (Level 2 Overlay)	1.91	0.77
3 (Level 2 Overlay)	1.54	0.73
4 (Micro-Surfacing)	1.30	1.21

PIN 9050.00 Limestone - Caswell IRI (m/km)		
Test Section	5/8/2001	10/30/2001
5 (Micro-Surfacing)	2.14	1.03
6 (Level 2 Overlay)	1.75	1.25

MDOT pavement smoothness specifications state that an IRI of 1.10 m/km is considered an average value and an IRI greater than 1.57 m/km requires remedial action by the contractor to correct the pavement surface. Pavement smoothness specifications were not enforced due to the uncertainty of the Micro-Surfacing process.

Test results reveal that Micro-Surfacing on project 9051.00 did not improve the ride as well as Level 2 treatments. Section 1 and 4 had a 4 and 7 percent improvement respectively compared to Section 2 and 3 that had a 60 and 53 percent improvement.

Test results on project 9050.00 were quite different. Section 5 had an improved ride of 52 percent compare to 29 percent for Section 6.

Annual smoothness tests will monitor the effect of traffic on each treatment.

Rut Depth

The following table contains rut depth measurements prior to and shortly after resurfacing.

PIN 9051.00 Presque Isle - Caribou Rut Depth (mm)		
Test Section	10/24/2000	10/31/2001
1 (Micro-Surfacing)	12.75	8.10
2 (Level 2 Overlay)	15.75	4.60
3 (Level 2 Overlay)	21.20	4.35
4 (Micro-Surfacing)	11.65	7.30

PIN 9050.00 Limestone - Caswell Rut Depth (mm)		
Test Section	10/24/2000	10/30/2001
5 (Micro-Surfacing)	9.95	6.00
6 (Level 2 Overlay)	10.15	3.90

Rut depth data reveals that Micro-Surfacing does not correct rutting as well as Level 2 resurfacing. The increased rut depth could be attributed to the raveling of surface aggregate in each wheel path shortly after opening the roadway to traffic. It was necessary to sweep loose aggregate off the surface prior to placing the scratch and wearing course.

Frictional Resistance

Frictional Resistance readings were randomly collected in the left wheel path along the length of each project. The following table contains a summary of frictional numbers for each treatment and project.

PIN 9051.00 Presque Isle - Caribou Frictional Resistance			
	Total Tests	Mean F.N.	Standard Deviation
Micro-Surfacing	16	53.3	1.49
Level 2 Overlay	20	47.5	3.00

PIN 9050.00 Limestone - Caswell Rut Depth (mm)			
	Total Tests	Mean	Standard Deviation
Micro-Surfacing	15	53.1	1.75
Level 2 Overlay	16	53.0	2.28

Frictional numbers of 35 or higher are considered by FHWA to be acceptable. Both surface treatments have similar frictional numbers with the exception of Level 2 Overlay on project 9051.00. In addition, the Micro-Surfacing treatment has a lower standard deviation resulting in a uniform surface.

Cost Analysis

Excluding the cost of traffic control and tack coat application, the cost of resurfacing with Micro-Surface was $2.18 / sq. meter and the product is expected to extend the life of the roadway from five to seven years. The cost and expected life span of Level 2 Overlay is $5.03 / sq. meter and eight to twelve years.

Annual evaluations will determine if Micro-Surfacing is a cost effective alternative to HMA overlays.

Additional Observations

A third Micro-Surfacing project, which will not be evaluated, is located in the town of Oakfield on I-95 SB. This project and the two experimental projects were exposed to winter conditions at the time of this report. After the first snowfall, it was reported that maintenance crews had a difficult time plowing snow off the Oakfield project. The plow blade would skip across the Micro-Surfaced pavement scoring portions of the surface. It was thought that a combination of new plow blades, height of plow shoes and angle of blade may have contributed to the scoring problem. Before the next storm, a different type of plow was used that had a less severe blade angle and the plow shoes were lowered. This helped reduce plow scoring.

All three projects had additional plow abrasion at the centerline and shoulder joint of the roadway. This type of abrasion was limited to the surface only.

Maintenance crews also noticed that the coarse nature of the Micro-Surfaced mix hindered removal of the snow and additional salt was used to accomplish the task.

PIN 9050.00 and 9051.00 will be evaluated over a five-year period. Interim reports will be published each year of the evaluation.

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Figure 1
PIN 9051.00 Crack Survey Section 1 Microsurfacing

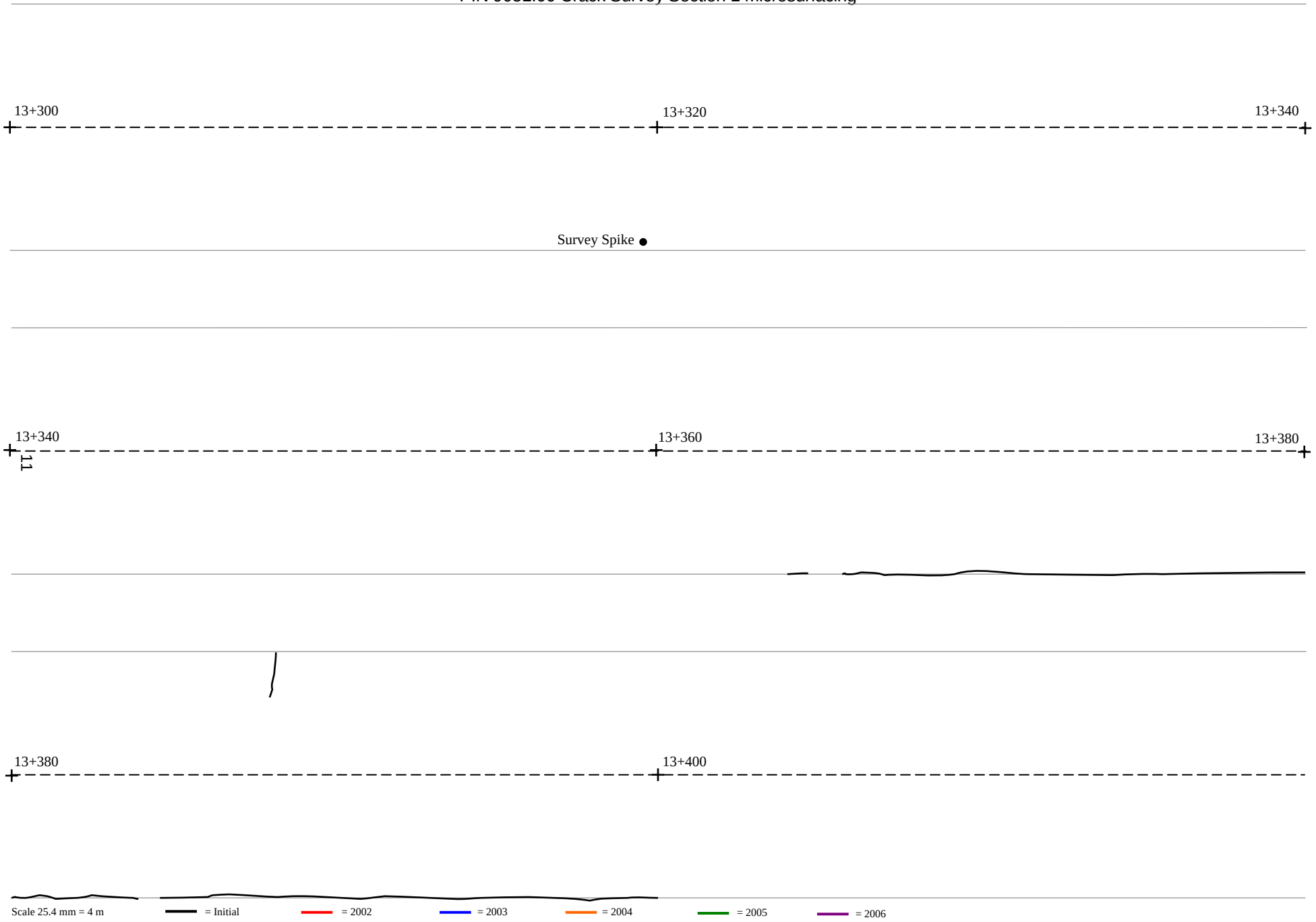

Figure 2
PIN 9051.00 Crack Survey Section 2 Control

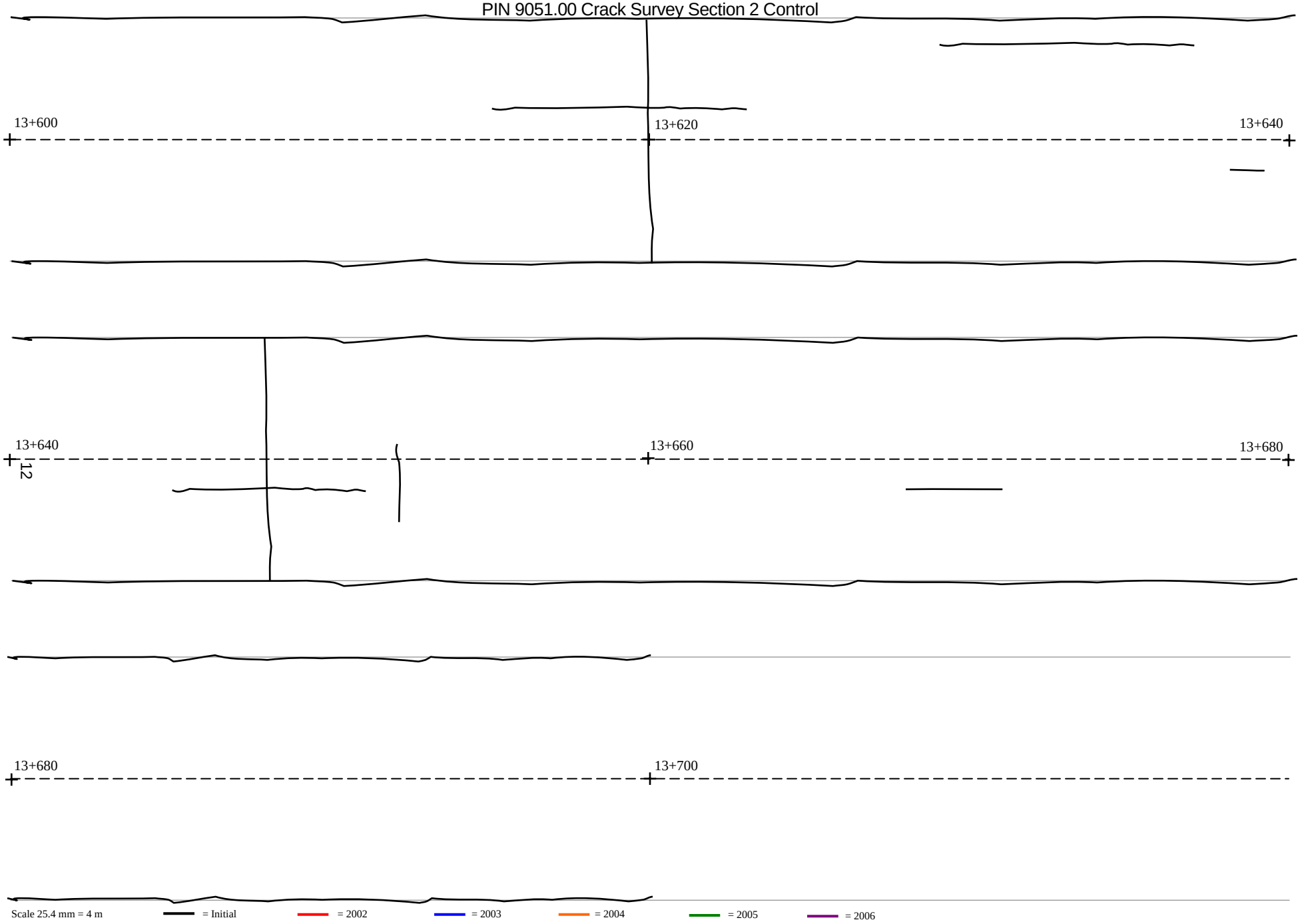

Figure 3
PIN 9051.00 Crack Survey Section 3 Control

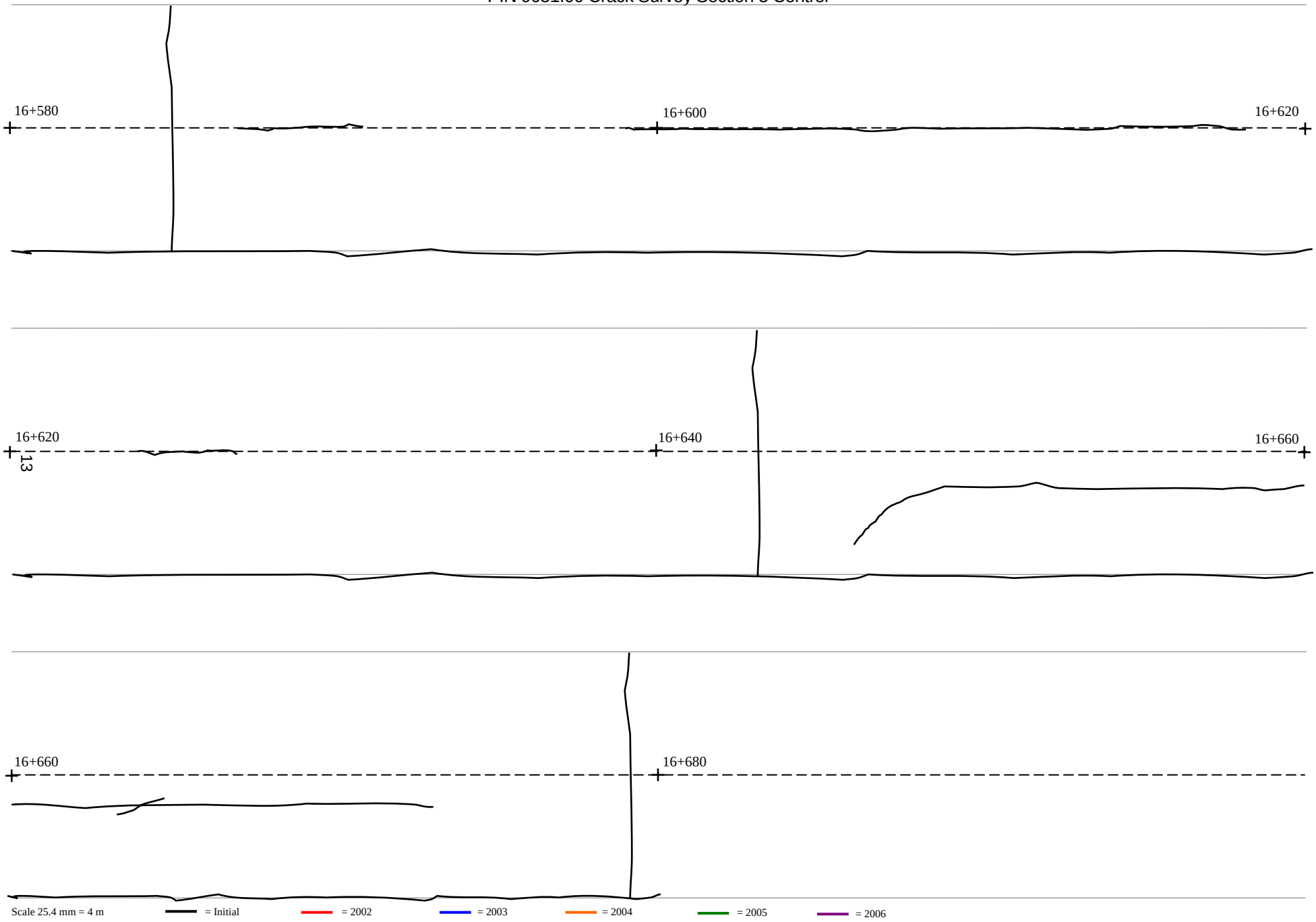

Figure 4
PIN 9051.00 Crack Survey Section 4 Microsurfacing

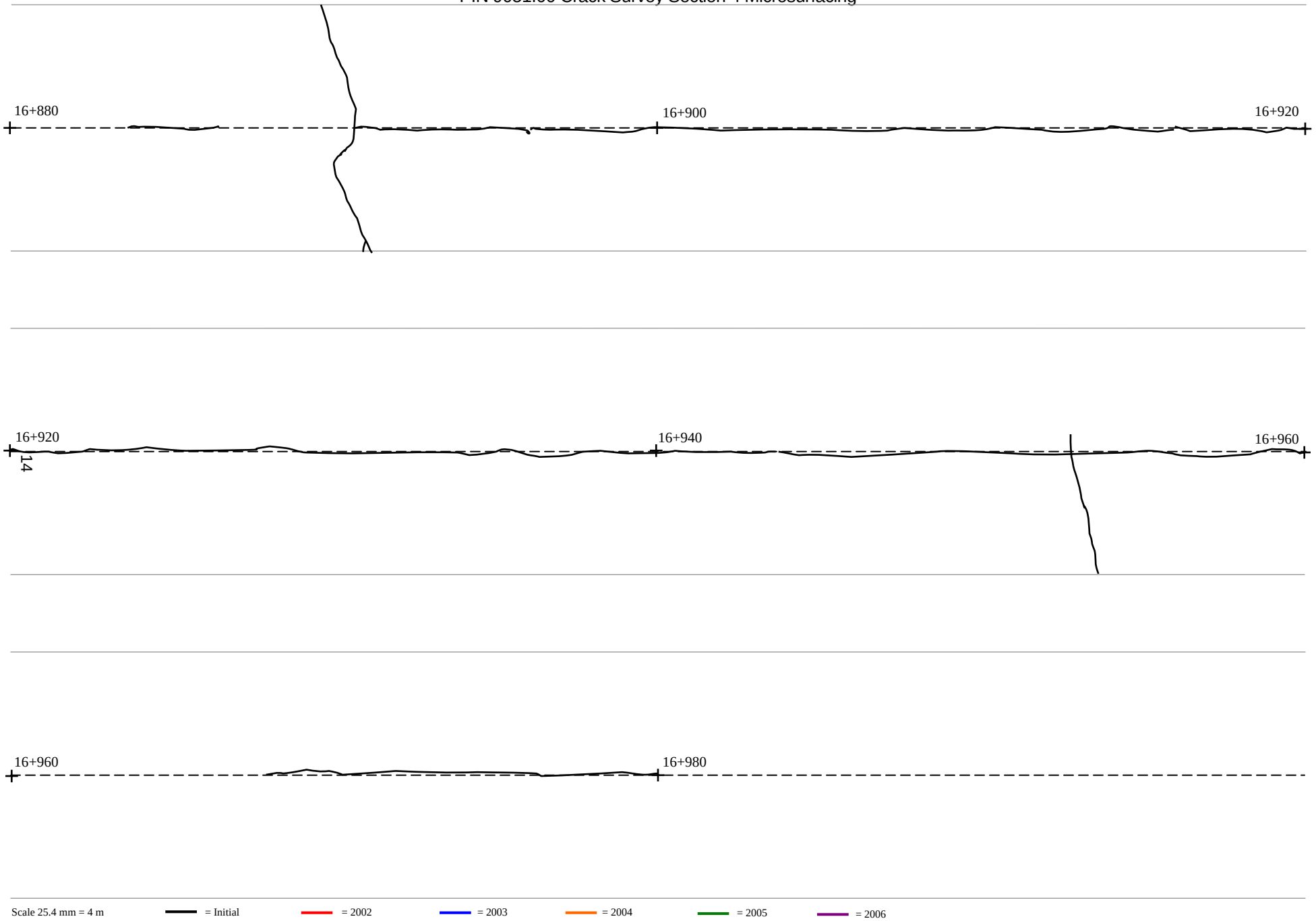

Figure 5
PIN 9050.00 Crack Survey Section 5 Microsurfacing

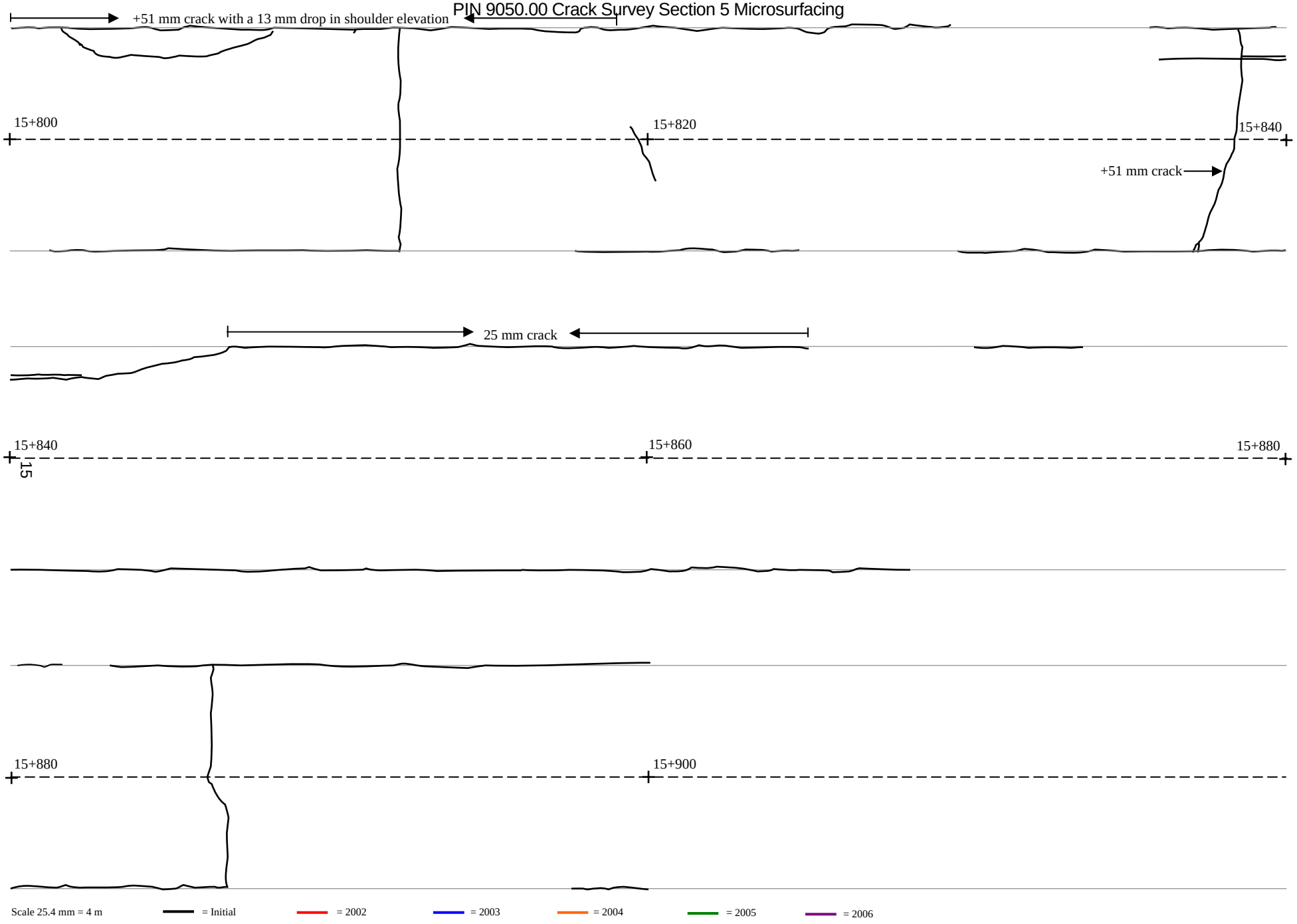

Figure 6
PIN 9050.00 Crack Survey Section 6 Control