Replace section 30-6 with:

30-6.01 PAVEMENT RECYCLING WITH INTELLIGENT COMPACTION

30-6.01A GENERAL

30-6.01A(1) Summary

Section 30-6 includes specifications for compaction of cold in-place recycling (CIR) utilizing intelligent compaction. This is a pilot project for evaluating intelligent compaction and the Department will not consider a VECP that substitutes the processes or equipment specified in this section 30-6. Intelligent compaction does not waive any specifications for CIR.

Intelligent compaction uses vibratory steel drum rollers with intelligent compaction equipment and static pneumatic tire rollers equipped with automated machine guidance system that provide the roller operator with real time information for quality control and produce data for standardized software Veta. For Veta, go to:

www.intelligentcompaction.com

Use Veta to analyze the data for coverage uniformity and intelligent compaction measurement values.

Effective April1, 2017, submit documentation that the technicians have completed one of the following Department authorized training courses within the last 12 months:

1. Intelligent compaction data analysis
2. Intelligent compaction Equipment

Intelligent compaction quality control technician must complete both trainings. Access the approved list of IC Training programs, Intelligent Compaction Quality Control Technicians, and Data Analysis Technicians at www.dot.ca.gov/hq/construc/ic

The Department furnishes project plan layout files in ___________ format. You may create project layout files for the intelligent compaction system, automated machine guidance system and Veta from the existing pavement using the GPS rover calibrated for the project site

Create project layout files from the project plans or you may create project layout files for the intelligent compaction system, automated machine guidance system and Veta from the existing pavement using the GPS rover calibrated for the project site.

Create project layout files from the as built plans or you may create project layout files for the intelligent compaction system, automated machine guidance system and Veta from the existing pavement using the GPS rover calibrated for the project site.

Create project layout files for the intelligent compaction system, automated machine guidance system and Veta from the existing pavement using GPS rover calibrated for the project site.

Project layout files must delineate the CIR construction area of the project.

30-6.01B Definitions

action limit: The minimum and maximum values of a quality control measurement that can be interpreted as representing acceptable performance with respect to the parameter being tested. Values less than the minimum or greater than the maximum action limit or level indicate that corrective action must be taken by the contractor.

all passes data: Compaction data that contain measurements from all passes.

automated machine guidance roller: Rollers equipped with measurement devices installed by the roller manufacturer or a post manufacture retrofit system including GPS, temperature sensor, on-board documentation system, and displays.

bonded layer: Pavement structural section material bonded in a matrix by asphalt, cement, or any other stabilization agent.

California coordinate system of 1983 (CCS83): A set of 6 geographic zones or coordinate systems designed for specific regions of the State of California, the boundaries of which follow county lines. CCS83 is based on NAD83. When a project crosses state plane zone boundaries, a single zone will be used for the entire project.

compaction data: Data collected by intelligent compaction equipment and automated machine guidance compaction equipment.

coordinated universal time (UTC): A time measurement system commonly referred to as Greenwich Mean Time (GMT) based on a 24-hour time scale from the mean solar time at the Earth's prime meridian (zero degrees longitude) located near Greenwich, England

coverage: Roller single pass over a given area.

dynamic cone penetration test: ASTM D6951 is used to assess in situ strength of undisturbed soil and compacted materials or both.

dynamic cone penetration index: The vertical movement of the dynamic cone penetration cone produced by one drop of the hammer, expressed in inch per blow.

final coverage: Compaction data that contain the last pass measurements for a given area.

foot: Unit of measurement equal to U.S. survey foot.

geodetic coordinates: A coordinate system to describe a position in longitude, latitude, and altitude above the imaginary ellipsoid surface based on a specific geodetic datum. The NAD83 datum is required for use with CCS83 State Plane Coordinates.

global positioning system (GPS): A space-based satellite navigation system that provides location and time information in all weather, anywhere on or near the Earth to determine the location in geodetic coordinates. GPS refers to all GPS-related signals including US GPS, and other Global Navigation Satellite Systems (GNSS). GPS satellite signals are subject to interference from canyons, buildings, trees or even fencing. Not all locations are suitable for GPS techniques, and it is your responsibility to determine if the site conditions are practical for GPS, and to notify the Engineer if they are not.

GPS base station: A single ground-based system consisting of a GPS receiver, GPS antenna, and telemetry equipment (typically radio and radio antenna or cellular phone) to provide L1/L2 differential GPS correction signals to other GPS receivers.

GPS correction service subscription: A service that can be subscribed to receive differential GPS correction signals for higher accuracy GPS positioning without the need of a GPS Base Station. Signals are normally received via cellular wireless data services. Examples of GPS correction service subscriptions are: Trimble VRS™, Leica Smart RTK™, Topcon TopNet™, OmniSTAR™, and California Real Time Network (CRTN).

GPS rover: A portable L1/L2 GPS antenna, mount, and receiver with telemetry equipment for Real Time in-situ point measurements.

GPS site calibration or localization: A process to establish a relationship between the observed GPS coordinates and the known grid coordinates.

grid: A Cartesian system of XY (or North-East) coordinates utilizing the California State Plane Coordinates, known as the California Coordinate System of 1983 (CCS 83).

intelligent compaction measurement value: A generic term for measurements of resistance to deformation of underlying material based on the responses of the roller drum vibrations in units specific to the roller manufacturer.

intelligent compaction equipment: Measurement devices installed by the roller manufacturer or a post manufacture retrofit system including accelerometer, GPS, temperature sensor, on-board documentation system, and displays.

intelligent compaction roller: Rollers equipped with measurement devices installed by the roller manufacturer or a post manufacture retrofit system including accelerometer, GPS, temperature sensor, on-board documentation system, and displays**.**

intelligent compaction target value: Compaction target values established at test strip or specified that are used by roller operator to monitor compaction and in data analysis to generate compaction quality control report.

network real time kinematic (Network RTK): A system of multiple bases in real-time to provide high-accuracy GPS positioning within the coverage area that is generally larger than that covered by a single GPS base station.

real time kinematic global positioning system (RTK-GPS): A system based on the use of carrier phase measurements of the available GPS signals where a single GPS base station or RTK network provides the corrections in order to achieve centimeter-level accuracy in real time.

roller pass: The area covered by one width of the roller in a single direction.

universal transverse mercator (UTM) coordinate system: Is a 2-dimentional Cartesian coordinates system that divides the surface of Earth between 80°S and 84°N latitude into 60 zones, each 6° of longitude in width and centered over a meridian of longitude. Zone 1 is bonded by longitude 180° to 174° W and is centered on the 177th West meridian. The UTM system uses projection techniques to transform an ellipsoidal surface to a flat map that can be printed on paper or displayed on a computer screen. Note that UTM is metric-based.

30-6.01C Submittals

30-6.01C(1) General

At least 15 days before mapping the existing pavement, you must register with the Department's secure file sharing system. To obtain information on the registration process, send an e-mail with your contact information to the following electronic mailbox address:

IC@dot.ca.gov

Forms for intelligent compaction submittals are available at:

http://www.dot.ca.gov/hq/construc/ic/

30-6.01C(2) Intelligent Compaction Training

30-6.01C(2)(a) Just In Time Training

Submit a list of names participating in the just-in-time training at the time of the mix design submittal. Identify each participant's name, employer, title, and role in intelligent compaction.

At least 10 days prior to just-in-time training, submit:

1. Just-in-time training presentation and handouts for review.
2. Completed *Intelligent Compaction Field Operations Just-In-Time Training Checklist* form
3. Completed *Geospatial Data and Analysis Just-In-Time Training Checklist* form
4- Name of Instructor

30-6.01C(2)(b) Intelligent Compaction Quality Control Technician Training

At least 15 days before performing intelligent compaction, submit the name of your intelligent compaction quality control technician independent of CIR production crew and the corresponding certification of training

30-6.01C(2)(c) Data Analysis Technician Training

At least 5 days before CIR production, submit the name of your data analysis technician and corresponding certification of training.

30-6.01C(3) GPS Site Calibration or Localization Report and Check Testing

Submit GPS site calibration or localization report and check testing results for compaction rollers within 1 business day of calibration, localization or check testing.

30-6.01C(4) Reports and Information

30-6.01C(4)(a) General

If unable to submit or upload report and information within the specified time, notify the engineer of the actions being taken to submit and upload information timely.

30-6.01C(4)(b) Reports

30-6.01C(4)(b)(i) Mapping Existing Pavement

At least 5 working days before sampling for mix designs for CIR, submit:

1. Hard copy of completed *Intelligent Compaction Cold-In-Place Recycling Mapping Summary Report*
2. Adobe *.pdf file of the mapping report by email to the Engineer using one of the following mapping procedures:
   - 2.1. Mapping with intelligent compaction roller for the existing pavement determined by mapping the existing pavement under section 30-6.03B(1).
   - 2.2 Mapping with coring and dynamic cone penetration determined by mapping the existing pavement under section 30-6.03B(2).

30-6.01C(4)(b)(ii) Test Strip

Within 1 business day of test strip submit:

1. Hard copy of *Intelligent Compaction Cold-In-Place Recycling Test Strip Submittals Summary*
2. Adobe *.pdf file of the test strip report by email to the Engineer
3. Adobe *.pdf file of *Intelligent Compaction Cold-In-Place Recycling Quality Control Report Checklist* form by email to the Engineer

30-6.01C(4)(b)(iii) CIR Compaction

Within 1 business day of CIR compaction submit:

1. Hard copy of completed *Intelligent Compaction Cold-In-Place Recycling Compaction Quality Control Report Summary*
2. Adobe *.pdf file of compaction quality control report by email to the Engineer
3. Adobe *.pdf file of *Intelligent Compaction Cold-In-Place Recycling Quality Control Report Checklist* form by email to the Engineer

30-6.01C(4)(c) Information

Within 3 business days of mapping, test strip, or CIR compaction:

1. Submit information on a digital medium to the Engineer.
2. Upload information to the Department's secure file sharing system
3. After uploading the compaction information to the Department's file sharing system, send an email notification of your electronic submittal to the Engineer and IC@dot.ca.gov with the appropriate completed checklist form as an attachment:
   - 3.1. *Intelligent Compaction Cold-In-Place Recycling Mapping Information Checklist*
   - 3.2. *Intelligent Compaction Cold-In-Place Recycling Test Strip Information Checklist*
   - 3.3 *Intelligent Compaction Cold-In-Place Recycling Quality Control Report Checklist*

30-6.01C(5) Data and Software Analysis Results

30-6.01C(5)(a) General

Not Used

30-6.01C(5)(b) Data

Submit mapping, test strip and compaction data elements in a format that is readable by Veta. You may combine roller data for multiple rollers operating in echelon into a section file.

Name the data file using:

YYYYMMDD_TTCCCRRR_DB_L_B_E_TOR_TC_T_Data

where:
YYYY = year

MM = Month, leading zero
DD = Day of month, leading zero
TT = District, leading zero
CCC = County, 2 or 3 letter abbreviation as shown in section 1-1.08 no leading zero
RRR = Route number, no leading zeros
DB = Traffic direction as NB, SB, WB, EB or PM for mapping
L = Lane number from left to right in direction of travel
B = Beginning station to the nearest foot (i.e., 10+20) or beginning post mile to the nearest hundredth (i.e., 25.06) maximum 6 characters with no leading zero.
E = Ending station to the nearest foot (i.e., 14+20) or ending post mile to the nearest hundredth (i.e., 28.06) maximum 6 characters with no leading zero
TOR = Type of reclamation “CIR” for cold in place recycling or “FDR” for full depth reclamation
TC= Type of compaction “PM” for mapping, “IC” for initial compaction or “SC” for supplemental compaction
T= Type of roller “R” for rubber tire or “SV” for steel drum with vibratory, “SS” for steel drum static, “SS-SV” for single roller combination of steel drum static and vibratory on.

Use the following header information for each compaction data file or section:

Item No.	Description
1	Section Title
2	Machine Manufacture
3	Machine Type
4	Machine Model
5	Drum Width (inch)
6	Drum Diameter (inch)
7	Machine Weight (ton)
8	Name index of intelligent compaction measurement values
9	Unit index for intelligent compaction measurement values
10	Reporting resolution for independent intelligent compaction measurement values – 90 degrees to the roller moving direction (inch)
11	Reporting resolution for independent intelligent compaction measurement values – in the roller moving direction (inch)
12	CCS83 Zone
13	Offset to UTC (hrs)
14	Number of compaction data points

Use the following data field names for each compaction data point:

Item No.	Data Field Name	Example of Data
1	Date Stamp (YYYYMMDD)	20080701
2	Time Stamp (HHMMSS.SS -military format)	090504.00 (9 hr 5 min. 4.00 s.)
3	Longitude (decimal degrees or degrees-minutes-seconds)	94.85920403
4	Latitude (decimal degrees or degrees-minutes-	45.22777335
5	Easting (foot)	6,096,666.000
6	Northing (foot)	1,524,166.650
7	Elevation (foot)	339.9450
8	Roller pass number	2
9	Direction index	1 forward, 2 reverse
10	Roller speed (mph)	2.0
11	Vibration on	1 for yes, 2 for no
12	Frequency (vpm)	3500.0
13	Amplitude (inch)	0.0236
14	Intelligent compaction measurement values	20.0

Note: Provide either items 3 and 4 or items 5 and 6

The GPS coordinate for each compaction data point recorded in data files must be at the center of the drum or center of the roller in front.

The size of the data mesh after post processing must be less than 1.5 feet by 1.5 feet in the X and Y directions.

30-6.01C(5)(c) Software Analysis Results

Analyze the compaction data daily using Veta and include nuclear gage data point tests, target values for passes, and intelligent compaction measurement values. For a sublot report, use sublot length of 528 feet.

For test strips and daily compaction quality control reports you must create and apply a boundary filter for the area of CIR to be analyzed to exclude extraneous intelligent compaction data. The boundary filter may be applied in the preprocessed raw roller data or created and applied in the Veta analyses. Create the boundary in Veta analyses by either importing GPS coordinates measured in the field from the boundary of the area of CIR production or by using the project layout and applying a filter to limit the analysis to the area CIR production.

Name report files and post processed Veta files using:

YYYYMMDD_TTCCCRRR_DB_L_B_E_TOR_TC_T_TYPE

where:
YYYY = year
MM = Month, leading zero
DD = Day of month, leading zero
TT = District, leading zero
CCC = County, 2 or 3 letter abbreviation as shown in section 1-1.08 no leading zero
RRR = Route number, no leading zeroes
DB = Traffic direction as NB, SB, WB, EB, or PM for mapping
L = Lane number from left to right in direction of travel
B = Beginning station to the nearest foot (i.e., 10+20) or beginning post mile to the nearest hundredth (i.e., 25.06) maximum 6 characters with no leading zero
E = Ending station to the nearest foot (i.e., 14+20) or ending post mile to the nearest hundredth (i.e., 28.06) maximum 6 characters with no leading zero

TOR = Type of reclamation “CIR” for cold in place recycling or “FDR” for full depth reclamation
TC = Type of compaction “PM” for mapping, “IC” for initial compaction, “SC” for supplemental compaction
T = Type of roller “R” for rubber tire, “S” for steel drum or “R-S” if data combined.
TYPE = Mapping report use “MAPPING_REPORT” for *.pdf files
    Test strip report use “TS_REPORT” for *.pdf files
    Compaction quality control report use “QC_REPORT” for *.pdf files
    Post processed Veta files use “VETA”

Plots must be scaled to be legible and must be 11 by 17 inches.

30-6.01C(5)(d) Mapping

30-6.01C(5)(d)() General

Not Used.

30-6.01C(5)(d)(ii) Mapping With Intelligent Compaction Roller

Analyze the intelligent compaction mapping data using Veta. Use the project layout to create a boundary of the area of mapping.

Report of mapping with intelligent compaction roller must include:

1. Mapping results on *Intelligent Compaction Cold-In-Place Recycling Mapping Report Summary* form
2. Color layout plots of intelligent compaction measurement value for the existing pavement
3. Color layout plots of intelligent compaction measurement value for soft areas with intelligent compaction measurement values equal or less than 2 standard deviation of the average intelligent compaction measurement value of the existing pavement
4. Final coverage histogram of intelligent compaction measurement value
5. Final coverage histogram of intelligent compaction measurement value for a 528 foot sublot

Mapping information must include:

1. Adobe *.pdf file of mapping report
2. Project layout and/or mapping boundary which can be imported to Veta
3. Electronic data from compaction rollers in file format readable by Veta
4. Post processed Veta file *.vetaproj used for creating the mapping report of the existing pavement
5. *Intelligent Compaction Cold-In-Place Recycling Mapping Information Checklist*

30-6.01C(5)(d)(ii) Mapping with Coring and Dynamic Cone Penetration

Use the results of dynamic cone penetration to identify each layers of structural section.

Report of mapping with coring and dynamic cone penetration must include:

1. Plot of pavement structural section profile based on cores
2. Plot of pavement unbonded layer dynamic cone penetration index profile
3. Locations of unbonded layer zone classified as “B” and “C”

Mapping information must include:

1. Adobe *.pdf file of mapping report.
2. Dynamic cone penetration index and the corresponding GPS coordinates which can be imported into Veta

30-6.01C(5)(e) CIR Test Strip

Test strip report must include:

1. Completed *Intelligent Compaction Cold-In-Place Recycling Test Strip Report Summary* form
2. Nuclear gage density readings and the corresponding GPS coordinates
3. All passes compaction curves from Veta
4. All passes correlation analysis plot from Veta
5. Field compaction curve density versus number of passes
6. Color layout plot of distribution of intelligent compaction measurement value over test strip
7. Color layout plot of distribution of pass count over test strip

Test strip information must include:

1. Adobe *.pdf file of the test strip report from data analysis performed using Veta software
2. Test strip boundary which can be imported to Veta
3. Nuclear gage density readings and the corresponding GPS coordinates which can be imported into Veta
4. Electronic data from compaction rollers in file format readable by Veta
5. Post processed Veta file *.vetaproj used for creating the test strip report
6. Adobe.* pdf file of *Intelligent Compaction Cold-In-Place Recycling Test Strip Information Checklist*

30-6.01C(5)(f) CIR Compaction

For each day of production, prepare a CIR compaction quality control report that includes:

1. Completed *Intelligent Compaction Cold-In-Place Recycling Compaction Quality Control Report Summary* form
2. Veta analysis report results for:
    - 2.1. Percent compliance with target roller passes
    - 2.2. Percent compliance with target CIR intelligent compaction measurement value of steel drum roller with vibratory on
3. Final coverage histogram of number of passes for each roller and histogram of intelligent compaction measurement value of steel drum roller with vibratory on.
4. Final coverage histogram of number of passes for each roller and histogram of intelligent compaction measurement value of steel drum roller with vibratory on for a 528 feet sublot.
5. All passes histogram for each roller
6. Color layout plots of:
    - 6.1. Roller passes for each roller
    - 6.2. Intelligent compaction measurement value for final coverage of intermediate compaction when required.
7. Quality control density measurements and corresponding GPS coordinate.

Plots must include quality control density testing locations and test results.

Compaction information must include:

1. Adobe *.pdf file of the compaction quality control report from data analysis performed using Veta software
2. Project layout data files which can be imported to Veta
3. Boundary data files which can be imported to Veta
4. Nuclear gage density readings and the corresponding GPS coordinates which can be imported into Veta
5. Electronic data from compaction rollers in file format readable by Veta
6. Post processed Veta data file *.vetaproj used for creating the compaction quality control

30-6.01D Quality Control and Assurance

30-6.01D(1) General

Not Used

30-6.01D(2) Technical Representative

A technical representative from the intelligent compaction equipment manufacturer and automated machine guidance system or post manufacture retrofit system must be on site during the initial setup and verification testing of the compaction rollers and the first 2 days of CIR production. If requested, the technical representative must assist the Engineer with data management using Veta including compaction data input and processing.

30-6.01D(3) Intelligent Compaction Training

30-6.01D(3)(a) Just-In-Time Training

Provide just-in-time training onsite or near the project site for your personnel and Department project personnel. Provide an enclosed facility with electrical availability for visual presentations. Schedule the just-in-time training with the Engineer at a mutually agreed time and place.

The Just in Time Training instructor must be in possession of a valid certification of Intelligent Compaction Quality Control Technician.

The just-in-time-training for intelligent compaction is divided into two sessions:

1. Intelligent compaction field operations
2. Intelligent compaction geospatial data and analysis

30-6.01D(3)(a)(i) Intelligent Compaction Field Operations Just-In-Time Training

Intelligent compaction field operations just-in-time training must be at least 2 hours in duration and include the following topics

1. Background information for the specific intelligent compaction system and automated machine guidance system to be used.
2. Setup and checks for compaction systems including:
    - 2.1. GPS receiver
    - 2.2. GPS base station
    - 2.3. GPS rovers
    - 2.4. Rollers
3. Operation of the intelligent compaction system and automated machine guidance systems on the rollers including:
    - 3.1. Setup data collection
    - 3.2. Start/stop of data recording
    - 3.3. On-board display options
4. Monitoring and communication
5. Action limits to be used by the roller operators for:
    - 5.1 Intelligent compaction measurement value
    - 5.2 Number of passes

The following personnel must attend field operations just in time training:

1. Roller operators
2. Intelligent compaction quality control technician
3. Technical representative
4. CIR foreman

30-6.01D(3)(a)(ii) Intelligent Compaction Geospatial Data and Analysis Just-in-Time Training

Intelligent compaction geospatial data and analysis just-in-time training must be at least 2 hours in duration and include the following topics::

1. Cover specification requirements for submittal of reports and information including file naming requirements Report Preparation
2. Report submittals
3. Information Submittals
4. Corrective actions to be taken when coverage and uniformity requirements are not met

The following personnel must attend intelligent compaction geospatial data and analysis just in time training:

1. Technical representative
2. Compaction quality control technicians
3. Data analysis technician
4. CIR foreman

30-6.01D(4) Prepaving Meeting

The Intelligent compaction quality control technician must attend the CIR prepaving meeting.

30-6.01D(5) Quality Control

30-6.01D(5)(a) General

For CIR placed under section 30-5, use intelligent compaction rollers and automated machine guidance rollers for documenting that CIR compaction complies with roller passes target values established at test strip.

The number of roller passes, temperature, and intelligent compaction measurement values are report only and not used for compaction acceptance.

30-6.01D(5)(a)(i) Quality Control Technician

During mapping, test strip, and CIR compaction, provide a full time intelligent compaction quality control technician.

The quality control technician is responsible for oversight of the following:

1. GPS site calibration or localization and upload to GPS receivers
2. GPS check testing for the compaction rollers and rovers
3. During test strip construction, determining the target values for compaction roller passes and target values for intelligent compaction measurement values
4. Construction operation monitoring of the compaction rollers
5. Quality control testing for compaction
6. Backing up compaction data twice per day
7. Downloading data from rollers at the end of the work shift
8. Exporting final coverage and all-passes data to Veta compatible form by using vendor specific intelligent compaction software
9. Monitoring daily compaction quality control report results for compliance with the requirements in these specifications and taking corrective action when necessary for compliance.
19. Daily set-up, take-down, of GPS and compaction roller components

30-6.01D(5)(a)(ii) Data Analysis Technician

Provide an intelligent compaction data analysis technician who is responsible for performing the following:

1. Analyzing the data from the compaction rollers using Veta and producing reports.
2. Submitting and uploading intelligent compaction reports and information.

30-6.01D(6) IC Test Strip

30-6.01D(6)(a) General

A test strip is used to establish CIR intelligent compaction target values for the following:

1. Number of roller passes for initial compaction for each type of roller
2. Number of roller passes for supplemental compaction for each type of roller
3. Intelligent compaction measurement value based on break over point density for CIR

The target number of roller passes is based on your roller pattern established to achieve break over point density.

30-6.01D(6)(a)(i) Establishment Target Value for Intelligent Compaction Measurement Value

On the first day of CIR production and within a 500 foot portion of the CIR test strip specified in section 30-5.01D(4)(b), construct IC test strip. Use handheld rover to establish boundary for the 500 foot section. Use handheld rover to establish 3 randomly selected nuclear gage density test locations.

Establish intelligent compaction target values for initial and supplemental compaction as follow:

1. After each roller pass, use a nuclear gage to measure the density at 3 preselected random locations throughout the covered 500 foot section. Record the roller pass number and density readings.
2. Establish the density of the tests strip for each coverage by averaging the density at the 3 locations
3. Continue roller passes and collecting nuclear gage density readings until the density remains constant, or decreases. The break over density target value is the maximum density on the plot of

test strip density versus number of passes for each coverage target value. The target number of roller passes is the number of passes for each roller in reaching the break over density.

4. After reaching break over density, use an intelligent compaction vibratory steel drum roller to make a last coverage of test strip with vibration on set at low amplitude. Use a nuclear gage to measure the density at 10 randomly selected locations throughout the 500 foot section. Record the density readings, and the GPS coordinates for each test location. Average the density readings and compare with break over point target value. Either of the following may apply based on the density test results:
   - 4.1. If the last coverage produces an increase in density above the break over point density, continue rolling with steel drum roller with vibration on until a new break over point density is determined. Use this new break over point density for production. Use pneumatic tire rollers to repair any damage caused by the intelligent compaction vibratory steel drum roller.
   - 4.2. If the last coverage produces a reduction in the compaction below the break point density:
     - 4.2.1. The requirement of maximum density will be waived on the 500 foot portion of the test strip.
     - 4.2.2. Use pneumatic tire rollers to repair any damage caused by the last single pass of the intelligent compaction vibratory steel drum roller.
5. Use Veta to create a compaction curve that relates the roller all passes to the intelligent compaction measurement values. The target value for intelligent compaction measurement value corresponds to last pass of the steel drum vibratory roller with vibration on based on your roller pattern.

30-6.02 MATERIALS

Not Used

30-6.03 CONSTRUCTION

30-6.03A General

Before CIR production, upload the project layout file into the compaction data analysis software and depending on the roller manufacturer, the on-board documentation system.

30-6.03A(1) Equipment

30-6.03A(1)(a) General

Use intelligent compaction rollers and automated machine guidance rollers for initial and supplemental compaction.

30-6.03A(1)(b) Rollers

For mapping existing pavement, the mapping roller must meet the following:

1. Be minimum 3 feet wide single or double-drum vibratory steel rollers with accelerometers mounted in or about the drum to measure the relative stiffness of the pavement.
2. Have GPS radio and receiver units mounted on roller to monitor the steel drum roller locations.
3. Include an integrated on-board documentation system that is capable of displaying real-time color-coded maps, including the stiffness response values, vibration frequencies, roller drum amplitude, roller location, roller speeds and capable of transferring stored data from a USB port.

For CIR, in addition to the requirements in section 30-5, intelligent compaction roller must meet the following:

1. Be double-drum vibratory steel rollers with accelerometers mounted in or about the drum to measure the interaction between the rollers and compacted materials in order to evaluate the applied compactive effort.
2. Be equipped with non-contact temperature sensors for measuring surface temperatures.
3. With vibratory on, produce output that represents the stiffness of the material based on the vibration of the roller drums and the measured response from the underlying materials.
4. Have GPS radio and receiver units mounted on each intelligent compaction roller to monitor the steel drum roller locations and track the number of passes of the rollers.
5. Include an integrated on-board documentation system that is capable of displaying real-time color-coded maps, including the stiffness response values, vibration frequencies, roller drum amplitude, roller location, number of roller passes, roller speeds and capable of transferring data from a USB port.

For CIR, in addition to the requirements in section 30-5, automated machine guidance pneumatic tire rollers must meet the following:

1. Be equipped with non-contact temperature sensors for measuring surface temperatures.
2. Have GPS radio and receiver units mounted on each automated machine guidance roller to monitor the roller locations and track the number of passes of the rollers.
3. Include an integrated on-board documentation system that is capable of displaying real-time color-coded maps of roller location, number of roller passes, roller speeds and capable of transferring data from a USB port.

30-6.03A(2) Global Positioning System

GPS must be real time kinematic using one of the following:

1. GPS base station
2. Network real time kinematic (RTK)
3. Satellite-based augmentation station system capable of providing position accuracy within 0.25 foot.

You may use other high precision positioning systems in lieu of GPS. The positioning system must meet or exceed the precision specified for GPS.

GPS used must provide a minimum 90 percent coverage of project site.

GPS devices for this project must be set to the same consistent datum, coordinate system, CCS83 zone, and site calibration or localization. The CCS83 zone must be set to zone no. __.

Prior to July 2016, you may use UTM coordinate system if your roller on-board documentation system and display are not compatible with CCS83. Notify the engineer if you will use UTM coordinate system.

30-6.03A(3) Correction Signal Source

Provide either a GPS base station correction signal or a GPS correction service subscription. The GPS correction signal must be received by the GPS receivers on the compaction roller and the rovers during operations with a survey tolerance of not greater than 0.25 foot in both X and Y horizontal directions.

Install GPS repeaters at selected locations to relate the GPS correction signal to resolve GPS shadows.

30-6.03A(4) Survey Control Points

Survey control points are indicated on the Project Control Map in the project plans.

Survey control points are included in Supplemental Project InformationRequest horizontal survey control points at least 15 days prior to GPS site calibration or localization. Survey control points will be provided at least every mile.

30-6.03A(5) GPS Site Calibration or Localization, Check Testing

Prior to mapping of the existing pavement, perform a GPS site calibration or localization to the survey control points.

Whenever the GPS base station is moved to a new location, verify GPS base station position by measuring the position of two known points using a rover. Perform a GPS site calibration or localization if the position of known points and measured positions differ by more than 3 centimeters.

At least 2 business days before start of production, perform roller verification testing by conducting roller check testing.

Before the start of daily production and using the same datum, conduct check testing for the proper setup of the GPS, the GPS of the rollers and the GPS rover:

1. On a location nearby or within the project limits, the GPS base station, if required by the GPS, must be established and the compaction roller and the GPS rover tied into the same base station
2. Verify that the roller and rover are working properly and that there is a connection with the base station
3. Verify the roller GPS coordinates by:
    3.1. Stopping the roller at a location

3.2. Marking the location of both ends of the roller drum or the outside of the front tires on the surface with a tee
3.3. Recording the GPS measurements from the roller ensuring the distance offsets are applied so that the GPS coordinate is at the center of the front drum or center of front axle.
3.4. Moving the roller from the marked location
3.5. Finding the mid-point of the 2 marked ends of the roller and mark this location on the surface. This marked location is the theoretical center of the front drum or the front axle.
3.6. Using the GPS rover to measure GPS coordinates of the marked location and record the GPS measurements
3.7. Computing the difference between recorded compaction roller GPS coordinates and GPS rover recorded GPS measured coordinates. The differences of the coordinates in grid must be within 0.50 foot in both the horizontal axes X and Y

30-6.03B Mapping Existing Pavement

Before sampling for mix design, map the existing pavement using intelligent compaction roller or coring and dynamic cone penetration testing.

30-6.03B(1) Mapping Existing Pavement with Intelligent Compaction Roller

Map the existing pavement with a single pass over the entire pavement using a mapping roller. Use low vibration amplitude and the same settings, including speed and frequency, throughout the section.

30-6.03B(2) Mapping Existing Pavement with Coring and Dynamic Cone Penetration

Obtain data for mapping the existing pavement structural section and unbonded layer stiffness as follows:

1. For structural section mapping, at 500 feet intervals obtain 6 inch cores of the bonded layers of the existing pavement at following locations:
   1.1. Center of each lane
   1.2. Center of each shoulder
   1.3. If cores show significant differences between consecutive intervals, such as different types of material or a variation of overall pavement thickness by more than 50 percent, the interval will be halved and cores will be taken at the half interval. Additional cores and dynamic cone penetration testing at the half interval will be change order work.
2. Remove and log the core of the pavement structural section
3. Use GPS rover to measure and record coordinates of each core location
4. At each core hole, perform ASTM D6951 using dual mass hammer (8.0 kg) on the unbonded layer for each location
5. Analyze dynamic cone penetration results in terms of the dynamic cone penetration indices as for each location as follow:
   5.1. Calculate dynamic cone penetration index for each 5 blows over the depth of 1.5 feet below the bonded layer or refusal. Refusal is 0.1 inch or less per blow.
   5.2. Calculate average and standard deviation of the dynamic cone penetration of indices at each core hole to identify uniform section and problem areas based on average dynamic cone penetration index shown in table below:

Average dynamic cone penetration Index (inch/blow)	Unbonded layer zone	Unbonded layer stiffness description
<0.7	A	Relatively strong
0.7-1.2	B	Marginal strength
>1.2	C	Weak, potentially wet

Map the existing pavement structural section and unbonded layer stiffness description as follows:

1. For each set of cores taken, plot the accumulative dynamic cone penetration index for over the depth of 1.5 feet below the bonded layers.
2. For each set of cores taken along the longitudinal axis of the area to be cold in place recycled, plot a pavement thickness profile and a lift thickness profile. Profiles will be electronically plotted at a horizontal scale of 1 inch equals 100 feet, and a vertical scale of 1 inch equals 1 foot.

3. For each set of cores taken transverse to the roadway of the area to be cold in place recycled, plot transverse pavement thickness and lift thickness cross sections. Transverse cross sections will be electronically plotted at a horizontal scale of 1 inch equals 5 feet, and a vertical scale of 1 inch equals 1 foot.
4. For unbonded layer stiffness, plot core location coordinates and unbonded layer stiffness description category for each core taken along the roadway longitudinal axis to be cold in place recycled. Mapping must be electronically plotted at a horizontal scale of 1 inch equals 100 feet for longitudinal plot.
5. For unbonded layer stiffness, plot core location coordinates and unbonded layer stiffness description category for each core taken along the roadway transverse axis to be cold in place recycled. Mapping must be electronically plotted at a horizontal scale of 1 inch equals 5 feet.

Backfill core holes with commercial cold mix and compact the material.

30-6.03C CIR Compaction

During compaction, monitor each roller's compaction graphical user interface display for roller passes and intelligent compaction measurement values.

Use GPS rover to measure and record coordinates of each quality control nuclear gage reading.

For each day of CIR production establish the boundaries of each lot of CIR production using the rover.

30-6.03C(1) Roller Coverage

At least 90 percent of the CIR production area must meet or exceed the target number of passes for each roller type determined from the test strip for that area. When the daily compaction quality control report shows the target number of roller passes are not met, take corrective action and notify the Engineer of action taken.

30-6.03C(2) CIR Intelligent Compaction Measurement Value

CIR Intelligent compaction measurement value is report only.

30-6.04 PAYMENT

Not Used