Make this section a part of the Standard Specifications:

"SECTION 621 – TRAFFIC COUNTING SYSTEM

621.01 Description. This work includes furnishing labor, materials, tools, machinery, and equipment necessary to restore two existing Traffic Counting Systems (TCS) complete in place according to the Contract. TCS 228 is a Continuous Vehicle Count (CVC) TCS that uses inductance loop sensors. TCS 438 is an Enhanced Vehicle Classification (EVC) TCS with piezoelectric sensors in addition to loop sensors. The Contractor shall restore the existing TCS as shown in the Contract, including the following:

(A) Provide for traffic counting and classification operations by installing piezoelectric sensors at TCS 438, and vehicle detector inductance loops (loop sensors) and cable wiring at TCS 228 and TCS 438. Existing cabinets and power sources are to remain.

(B) Provide underground conduit systems including trenching and structural excavation, backfilling, and restoration work. Furnish and install new pull box at TCS 228. Protect and reuse existing pull boxes and conduit as shown in the Contract documents and as directed by the Engineer.

(C) Coordinate work with and arrange for inspection of work by the Engineer. Arrange for a representative from the piezoelectric sensor's manufacturer to supervise installation of piezoelectric sensors.

(D) Conduct required testing of the loop sensors and piezoelectric sensors. Submit acceptance test procedures and criteria for acceptance test results to the Engineer. Notify the Engineer a minimum of 1 week before the date scheduled for testing.

(E) Turn over to the Engineer two complete and operating TCS Stations according to the Contract.

Furnish and install incidental parts necessary to complete the TCS Stations as though such parts were in the Contract.

621.02 Materials. Electrical equipment shall conform to the NEMA Standards and this Contract. Materials and workmanship shall conform to the National Electric Code (NEC), General Order Nos. 6 and 10 of the Hawaii Public Utilities Commission, ASTM standards, the ANSI, and applicable revisions for all the above codes, standards, and local ordinances that may apply.

(A) Piezoelectric Sensors (Piezo Sensors).

(1) Piezo sensors shall meet the following conditions:

(a) Be Class I BL Weigh-in-Motion unencapsulated piezoelectric sensors.

(b) Have a minimum operating life of 1 year from the date of acceptance.

(c) Meet the requirements as outlined in the FHWA document *A Summary of Vehicle Detection and Surveillance Technologies Used in Intelligent Transportation Systems*.

(d) Be of the length shown in the Contract documents (or as determined by the Engineer).

(e) Be manufactured complete with the piezo sensor lead cable and the sensor itself as one integral unit.

(f) Have a 16 gauge, flat, braided, silver plated copper wire center core that is spiral-wrapped by PVDF piezoelectric film.

(g) Have an outer sheath of 0.16-inch thick brass meeting CDA-260, as required by ASTM B587-88, *Standard Specification for Welded Brass Tube*.

(h) Be approximately 0.26 inches wide, with a maximum thickness of 0.063 inch (plus/minus 0.005 inch).

(i) Have insulation resistance between core and shield greater than 500 megaohms.

(j) Have a nominal piezoelectric coefficient greater than or equal to 20 pC/N.

(k) Have designs and installation techniques proven reliable in conditions (soil and environmental) similar to those in Hawaii.

(l) Be able to withstand at least 1 million cycles.

(m) Have a compatible interface with the electronics housed in the EVC controller cabinet to perform the applications required for the EVC System.

(n) Include all mounting hardware and PU200 piezo installation resin (or equivalent) used for installation.

(2) The piezo sensor lead cable to the EVC controller cabinet shall meet the following conditions:

(a) Be manufactured complete with the piezo sensor lead cable and the sensor itself as one integral unit.

(b) Be RG58 type, rated for underground direct burial.

(c) Have an outer jacket of 0.187 inch outside diameter.

(d) Have a nominal capacitance of at least 27 pF/ft.

(e) Be field measured so that the length of piezo sensor lead cable ordered suits the installation conditions.

(f) Be sufficiently long to reach the EVC controller cabinet with at least an additional 12 inches extra slack within the cabinet. Excess piezo lead cable, beyond the 12 inches of slack, shall be trimmed in the field during installation.

(g) The maximum length of piezo passive cable shall be 300 feet and splicing of the piezo sensor lead cable will not be allowed under any condition.

(3) The supplied PU200 piezo installation resin (or equivalent) shall meet the following conditions:

(a) Be suitable for installation in both Asphalt Concrete and Portland Cement Concrete pavements.

(b) Have a short curing time (less than 75 minutes) to minimize lane closure time.

(c) Be of sufficiently thick consistency to prevent ‘running’ when being applied in saw cuts.

(d) Be uniform in consistency such that particulate matter within the sealant does not separate or settle.

(e) Be approved by the piezo sensor manufacturer and the Engineer.

(4) An appropriate in-road Temperature Sensor shall be supplied to provide temperature correction data for the piezo sensors. The temperature sensor shall be an in-road sensor, as approved by the Engineer.

(B) Loop sensors.

(1) Loop sensor wire shall meet the following conditions:

(a) Be 14 AWG stranded THHN.

(b) Be 600 Volts rated.

(c) Be IMSA Spec.51-3 certified.

(d) Be tested at the factory prior to shipment.

(e) Include installation materials and loop sealant for installation.

(2) Loop sensor home-run cables shall meet the following conditions:

(a) Be polyethylene insulated.

(b) Be stranded-tinned-copper 14 AWG.

(c) Be a 2-conductor cable.

(d) Have a stranded-tinned-copper drain wire.

(e) Be aluminum–polyester shielded.

(f) Be polyethylene jacketed.

(g) Be 600 Volts rated.

(h) Be IMSA Spec. 50-2 certified.

(i) Be tested at the factory prior to shipment.

(j) Be sufficiently long that the loop sensor home-run cable is one piece that reaches all the way from the pull box (where it is spliced to the twisted-pair of loop wires) to the TCS controller cabinet. The cable length shall allow for a service loop of 5 feet of extra slack in pull boxes for each

loop sensor home-run cable, and an extra 12 inches slack inside the cabinet. Splicing of the home-run cable to the twisted-pair of loop wires shall only be allowed at the closest pull box to the loop. Splicing must be done by use of a splice kit.

(3) The supplied loop sealant shall meet the following conditions:

(a) Shall be compatible with IMSA Spec. 51-3 loop detector wire.

(b) Be manufactured as ready to install and not require any mixing.

(c) Be suitable for installation in both Asphalt Concrete and Portland Cement Concrete pavements.

(d) Have a short curing time (less than 75 minutes) to minimize lane closure time.

(e) Be uniform in consistency such that particulate matter within the sealant does not separate or settle.

(f) Be approved by the Engineer.

(C) Backer Rod. The Contractor shall use 3/8-inch to 1/2-inch diameter backer rod to secure loop sensor wires and twisted-pair loop lead-in wires at the bottom of saw cuts as shown on Contract documents.

(D) Conduits. The Contractor shall use steel electrical conduits for all exposed construction. PVC conduits shall be used for all underground construction. All new direct-burial PVC conduits shall be Schedule 80. PVC conduits under pavement and at utility crossings shall be concrete encased. Concrete-encased PVC conduits can be Schedule 40. Trenched conduits shall conform to Standard Plan TE-36 or as directed by the Engineer.

(1) Steel Conduits. Steel conduits shall meet the conditions of Subsection 712.27(A) – Steel Conduits of the Standard Specifications.

(2) PVC Conduits. PVC conduits shall meet the conditions of Subsection 712.27(B) – Plastic Conduits of the Standard Specifications.

(3) Conduit Sealing Compound. Conduit sealing compound meet the conditions of Subsection 712.27(E) – Duct Sealing Compound of the Standard Specifications.

(E) TCS Cabinets. The existing controller cabinets shall be used for the restored TCS stations.

(F) Power. Power shall be restored from the existing electrical connection in accordance with the power company's requirements for electrical service at TCS 438. Power from the existing solar assembly shall be restored at TCS 228.

(G) Pull Boxes and Covers. New pull box covers shall be labeled TRAFFIC MONITORING. This label shall be cast or molded into the cover material and not just marked on the cover surface. The existing pull boxes to remain and be reused. The new pull box and cover at TCS 228 in the paved median shall be rated for the largest potential vertical load they might encounter, or by direction of the Engineer.

Other Materials. Other materials shall meet the requirements specified in the following sections of the Standard Specifications:

Structural Concrete	Section 601
Reinforcing Steel	Section 602
Trench Backfill Material	Subsection 703.21
Concrete Pull Box	Subsection 712.06(B)

621.03 Construction Requirements.

(A) Equipment List and Drawings. Submit within 7 days following Contract award, two copies of materials and equipment purchase requisition, including copies of the equipment list, manufacturer's brochures, catalog cuts, and shop drawings to the Engineer for acceptance.

Order materials and equipment immediately upon acceptance by the Engineer. If the Contract award is rescinded by the Department after ordering of materials and equipment, the Department will purchase ordered materials and equipment at cost based on invoices. Purchase price will include transportation cost and applicable State excise taxes. Purchase price will not include profit.

Upon completion and acceptance of work, submit an 'As Built' or corrected plan showing in detail any construction changes per Section 648 – Field Posted Drawings.

(B) Excavation and Backfill. Excavate and backfill in accordance with Section 204 – Excavation and Backfill for Miscellaneous Facilities. Place the material from the excavation to prevent damage and obstruction to vehicular and pedestrian traffic and interference with surface drainage.

(C) Installation. The Contractor shall notify the State and schedule a meeting at least 14 days prior to any construction activity. Installation of sensors shall occur after any and all grinding and or milling of the finished pavement surface.

(1) Piezo Sensors.

(a) Installation shall be supervised by the piezo sensor manufacturer's representative.

(b) Construction shall reflect the number and configuration for the piezo sensors as shown in the Contract documents.

(c) Piezo sensors and leads shall be installed at least 18 inches away from cracks, potholes or joints within the pavement. If the finished pavement at the installation site has cracks, potholes or joints, the number and configuration of piezo sensors shall be modified.

(d) Piezo sensors shall be installed within the roadway, two each per lane, in both traffic directions. Refer to the configuration shown in the Contract documents.

(e) If the sensor configuration needs to be modified, the Contractor shall inform the State 14 days before the start of construction and submit Shop Drawings of the revised configuration for approval.

(f) Use a 3/4-inch thick saw blade to make a 3/4-inch wide by 2-inch deep slot for the piezo sensor in a single pass of the saw. The slots shall be made as shown in the Contract documents, or as approved by the Engineer.

(g) Use a 1/4-inch thick blade to make a 1/4-inch wide slot for the piezo sensor lead cable. The depth of the slot shall be as shown on the Contract documents.

(h) Saw cuts shall be made by wet cutting. Dry cutting shall not be allowed.

(i) Clean away collected dust, dirt, and refuse promptly after saw cutting is done. The saw cuts shall be cleared by water applied by pressure washer. Residual water within the saw cuts shall be vacuumed by use of a wet/dry vacuum. The saw cuts shall then be dried by air compressor. Flame torches shall not be used to dry saw cuts. After the slots are dried, any remaining debris stuck within the slot must be removed. The saw cuts must be completely clean and dry before inserting the piezo sensors and lead-in cables.

(j) Inspect saw cuts before inserting the piezo sensors. If any additional debris or moisture is observed, use compressed air to dry the slots and remove any additional debris before proceeding with installation.

(k) Piezo sensors shall be tested and cleaned prior to installation according to manufacturer’s installation instructions.

(l) Lay piezo sensor in saw cut at 1-1/4 inch below the surface of the roadway or as recommended by the manufacturer. Install piezo sensor straight and flat in saw cut. Secure sensor in place along the entire length of the sensor in the slot by seating it in the slot with the clips provided in the sensor kit from the manufacturer. The clips shall be spaced 6 inches apart.

(m) Fill voids of the piezo sensor saw cuts with PU200 piezo installation resin (or equivalent) so that the piezo sensor is fully encapsulated. The PU200 piezo installation resin (or equivalent) shall be prepared in accordance with the manufacturer's instructions and shall result in a finish approximately 1/16 inch above the surface of pavement. Once the resin has sufficiently hardened, the epoxy sealant shall be ground flush with the road surface along the saw cut.

(n) Hot tar shall not be used.

(o) Provide a service loop of 5 feet of extra slack in the pull box for each piezo lead cable.

(p) Trim piezo lead cables after allowing for an extra 12 inches of slack inside the TCS controller cabinets. Splicing to lengthen the piezo lead cable will not be allowed under any condition and spliced piezo lead cables will be rejected.

(q) The in-road temperature sensor shall be installed according to the manufacturer's installation instructions, as approved by the Engineer.

(r) Provide adequate power for all test equipment to meet the detailed and specific requirements of the manufacturer for all tests required for certification and acceptance. Provide all necessary equipment to perform the required tests.

(s) Traffic shall not be allowed on the completed system until the manufacturer's representative approves all conditions of the installation with the acceptance by the Engineer. Thereafter, testing in accordance with the manufacturer's requirements shall be completed before public traffic is allowed.

(2) Loop Sensors.

(a) Construction shall reflect the number and configuration of loop sensors as shown in the construction plans.

(b) Loop sensors and their twisted-pair leads shall be installed at least 18 inches away from cracks, potholes or joints within the pavement. If the finished pavement at the installation site has cracks, potholes or joints, the number and configuration of the loop sensors shall be modified.

(c) If the configuration of the loop sensors needs to be modified, the Contractor shall inform the State 14 days before construction and submit Shop Drawings of the revised configuration for approval.

(d) Loops shall be installed two per lane to measure speed and length of vehicles at both TCS stations, and to classify vehicles in conjunction with the piezo sensors (at TCS 438). Install loop sensors such that they are centered in

lanes relative to the final lane striping. Loop sensors not installed centered in each lane relative to the final lane striping shall be replaced correctly at no additional cost to the State. If lanes are less than 12 feet in width, the loop configuration may be specified as staggered or a non-centered configuration. Refer to the configuration specified in the Contract documents.

(e) Use a 3/8-inch to 1/4-inch thick blade to make 4-inch deep slots for the loop saw cuts.

(f) Saw cuts shall be made by wet cutting. Dry cutting shall not be allowed.

(g) Clean away dust, dirt, and refuse promptly after saw cutting is done. The saw cuts shall be cleared by water applied by pressure washer. Residual water within the saw cuts shall then be vacuumed using a wet/dry vacuum. The saw cuts shall then be dried by air compressor. After the slots are dried, any debris stuck within the slot must be removed.

(h) The loop sensor and lead wire shall be one continuous piece of wire, from the pull box, to the loop, around it four turns, and back to the pull box. The size of loops is specified in the Contract documents.

(i) Twisted-pair loop leads shall be twisted five twists per foot their full length, from the loop to the pull box, where they will be spliced to the home-run cable. The twisting shall be completed prior to inserting the resulting twisted-pair loop lead into the conduit leading to the pull box.

(j) A twisted pair of loop leads from one loop sensor shall not be twisted with the twisted pair from another loop sensor.

(k) After laying the four turns of loop sensor wire in the bottom of the 4-inch deep saw cut, press 1-inch long pieces of backer rod in each foot around the loop, to anchor the wires in the bottom of the slot before applying the loop sealant. Place backer rod pieces on top of the twisted-pair leads as was done around the loops, to anchor the twisted-pair leads in the bottom of saw cuts from loops to the edge of the pavement. Backer rod shall be embedded at least 2 inches below the top of pavement. The backer rod shall be placed into the saw cut with a blunt object, such as a

wooden stir stick. No sharp object, such as a screwdriver, shall be used to place backer rod into saw cuts.

(l) Loop sealant shall be applied to saw cuts with an applicator gun so that there are no voids, completely filling the slot, and such that the sealant will cure flush with the road surface.

(m) The twisted-pair lead-in wires from the loop sensors shall be spliced (as directed by the Engineer) to new home-run cables at the pull box using a splice kit. The splice kit shall be used in accordance with the manufacturer's specifications. The splice shall be inspected by the Engineer before acceptance. Splice points of cables must be suspended near the top of the pull box with a j-hook or equivalent.

(n) Provide a service loop of 5 feet of extra slack in the pull box for each loop sensor home-run cable.

(o) Trim loop sensor home-run cables after allowing for an extra 12 inches of slack inside the TCS cabinet.

(p) HDOT or its representative will make the final connection inside the TCS cabinets; however, the Contractor shall label the wires clearly to identify traffic direction, lane number, and sequence of loops and piezo sensors in each lane per direction. All labeling at pull boxes and cabinets must be consistent.

(3) Pull Boxes. Protect the existing pull boxes to be reused, as indicated in the Contract documents. Furnish and install the new pull box at TCS 228 as indicated in the Contract documents. Carefully excavate the area for the new pull box.

(4) TCS Cabinets. Protect the existing controller cabinets to be reused, as indicated in the Contract documents.

(5) Conduits. Protect the existing conduits to be reused, as indicated in the Contract documents.

(a) Install new conduits to drain towards the pull box. Conduits shall not drain towards TCS cabinets.

(b) Make directional changes in the conduits, such as bends and changes to clear obstructions with curved

segments using accepted deflection couplings or with short lengths of straight conduits and couplings. The deflection angle between two adjacent lengths of conduit shall not exceed 6 degrees. The bends shall not have a radius of less than 12 times the nominal size of the conduit. The Contractor may use factory-made ells.

(c) Cut the rigid PVC conduits with a hacksaw. Square and trim the ends after cutting to remove rough edges. The connections shall be of the solvent weld type. Make the solvent weld joints according to the conduit manufacturer's recommendations and as accepted.

(d) Seal the ends of the conduit with plugs at the end of each day of work, whenever problems interrupt the conduit installation work, and whenever conduits are subject to submergence in water.

(e) Keep the conduits clean during construction.

(f) Conduits under pavement and at utility crossings shall be trenched and concrete encased, per TE-36. Metallic Excavation Warning Tape shall be placed above the conduit per TE-36.

(g) Use only hand shovels in compacting concrete encasements. Cure the concrete for at least 72 hours before permitting vehicular traffic to run over the concrete.

(h) Give the exterior portions of the direct-burial steel conduits not encased in concrete two coats of asphaltic base paint.

(i) The entire length of a conduit run between pull boxes or between pull boxes and cabinets shall be of one type of material.

(j) The completed conduits shall be subject to a field test. Pass a bullet-shaped test mandrel about 14 inches long with a diameter 0.5 inch less than the inside diameter of the conduits through the entire length of each conduit run. The Engineer will consider scouring found on the mandrel deeper than 1/32 inch an indication of burrs and/or obstructions in the conduit run. Normal abrasion between the conduit line and bottom of mandrel is not an indication of burrs and/or obstructions in the conduit run. Remove such burrs and/or

obstructions. Pass the test mandrel through again. Repeat the process until the Contractor gets a satisfactory result.

(k) Provide each conduit run with a No.10 gauge flexible, zinc-coated pull wire (or 1/8" polyester or polyolefin pull wire) extending through its entire length. Double an additional 5 feet back into the conduit at each end of the run. Conduits and sleeves entering pull boxes shall end flush in the wall with ends ground smooth. Plug the conduits and sleeves temporarily.

(6) Wiring.

(a) Wiring shall conform to the appropriate articles of the NEC. Arrange the wiring within assemblies and pull boxes neatly. Wiring installed underground must be in conduits—no direct burial. Before the final installation of cables in conduits, pull a wire brush, swab, and mandrel through each conduit, to ensure that extraneous matter has been removed, and to verify that the conduit system is clean and free from obstructions.

(b) Handle the cables with great care to avoid damage to the conductors or the jacket. Do not pull off and lay the cables on the ground before installation. Make the pulls in one direction only. Lubricants used shall be as recommended by the cable manufacturer or accepted by the Engineer. Do not leave wires or cables under tension nor tight against bushings or fittings.

(c) Remove damaged ends resulting from the use of pulling grips soon after pulling conductor and cable. Temporarily tape or cap cable ends to exclude moisture. The cable ends shall remain protected until the Contractor attaches the terminal equipment. The Contractor shall submit brochures for cable connections in the controller cabinet for acceptance.

(d) The Contractor shall permanently tag and label all lead-in wires and cables in the TCS cabinets and at pull boxes according to the Contract.

(D) Bonding and Grounding.

(1) Secure metallic conductor and cable sheaths and conduits mechanically and electrically to form a continuous system.

(2) Ground system in accordance with the NEC and as specified herein. Provide No. 8 AWG copper wire or equivalent copper strap of same cross-sectional area for bonding and grounding jumpers.

(3) Ground conduits and neutral wires at service points as required in accordance with the NEC, using No. 6 AWG or equal for grounding conductors.

(4) Connect grounding rods with No. 6 AWG wire to No. 8 AWG ground wire loop and power system neutral.

(5) On wood poles, ground equipment mounted less than 8 feet above ground surface.

(E) Power Service. Restore existing electrical utilities in accordance with the power company's requirements for electrical service at TCS 438. Power from the existing solar assembly shall be restored at TCS 228.

(F) Inspection and Testing.

(1) Before Installation. The equipment shall be given requisite factory tests and inspected by the contractor upon receipt to determine that the workmanship and materials are free from defects.

(2) After Installation.

(a) After installation of piezo sensors, perform and furnish hard copy test results for each piezo sensor showing:

1) Resistance: The resistance shall be at least 1 megaohm.

2) Capacitance: The capacitance shall range from 5 to 20 nanofarads.

3) Dissipation Factor: The reading shall be less than 0.04.

(b) After the installation of the loop sensors, perform and furnish hard copy test results for each loop sensor showing:

1) Induced voltage (V).

2) f = Frequency of Loop (kHz).

3) L = Inductance of Loop (µH).

4) R = Resistance of Loop (ohm).

5) Meg Test = Loop insulation resistance shall be greater than 100 megaohms.

Provide all testing equipment such as BK 875A or equivalent LCR meter, Fluke 75 or higher/equivalent multimeter, megohmmeter, and scope meter or oscilloscope for the above tests.

Correct any defects discovered as a result of the sensor tests at no additional cost to the State.

(3) Acceptance of TCS Stations. The TCS Stations shall not be accepted and payment shall not be made until the systems have successfully met the required testing and test results have been submitted to the State within 30 calendar days from the completion of sensor installation.

(G) Restoring Pavements and Other Improvements. Restore existing pavements and other improvements disturbed by excavation to their original condition. Use replacement material equal to or better in quality than existing materials. Match existing grades, thickness, texture, and color as indicated in the construction plans.

(H) Warranty. Provide new material and equipment for permanent construction as indicated in the construction plans. Furnish copies of manufacturer's warranty or warranties guaranteeing equipment free from defects in materials, design, and manufacturing, for not less than 12 months from the date of acceptance. Adjust or repair material and equipment under warranty within 24 hours from time of notification. Temporarily replace under-warranty material and equipment requiring factory corrections within 24 hours from time of notification. Install factory-corrected or new material and equipment no later than 30 days from time of notification.

621.04 Method of Measurement. The restoration of each TCS station will be paid for on a lump sum basis. Measurement for payment will not apply.

621.05 Basis of Payment. The Engineer will pay for each accepted TCS station restoration on a lump sum basis. Payment will be full compensation for the work prescribed in this section and the Contract documents.

The Engineer will pay for the following pay item when included in the proposal schedule:

Pay Item	**Pay Unit**
Restore TCS 228	Lump Sum
Restore TCS 438	Lump Sum”

END OF SECTION 621