Master Specification: District Hub (DHU) V1.1

Role: District Director & Edge Coordinator | **Tier:** Layer 2 (Regional Mesh Manager) | **Radius:** 10km (Line-of-Sight)

The District Hub (DHU) operates as the primary "Director" and traffic coordinator of the FarmSense network. Positioned atop high-elevation structures across Subdistrict 1, the DHU provides the high-bandwidth backhaul connectivity, localized edge processing, and multi-node mesh coordination required to keep the "Digital Water Ledger" synchronized across thousands of acres. While the VFA acts as the field-level truth, the DHU is the central nervous system node that bridges the gap between raw field data and the high-performance computing clusters at the Regional Superstation (RSS).

Network Topology & High-Availability Backhaul: Each DHU covers a 10km radius zone, managing up to 100 VFA/LRZ field deployments. To ensure 99.9% data availability, the DHU employs a **"Fiber-First" Backhaul Mandate**: in any location where fiber internet can be installed within a cost-effective trenching or aerial distance, it must be utilized as the primary uplink. For sites beyond the fiber footprint, or as a critical failover for fiber-connected sites, the DHU utilizes a **Pay-As-You-Go IoT Cellular (LTE-M/NB-IoT) or Satellite (Starlink) array**. This ensures that even during regional fiber cuts or severe weather events, the critical water accounting data remains synchronized.

1. Enclosure Engineering & Siting Dynamics

The DHU is engineered for a 40-year structural lifespan, utilizing utility-grade standards to ensure signal integrity across the San Luis Valley's intense thermal and wind gradients.

- **The Enclosure (The Oversized Thermal Buffer):** A **NEMA 4X Rated Oversized Polycarbonate Enclosure (24"x20"x10")** from Polycase.
    - *RF-Transparency:* Polycarbonate is mandated over steel to allow internal diagnostic radios, GPS modules, and high-gain BLE antennas to maintain locks through the housing, significantly reducing the external cable entry points where moisture or lightning could strike.
    - *Thermal Mass Management:* The oversized volume is a strategic requirement. It provides a massive internal air-gap for the 200Ah battery system, acting as a passive thermal buffer against the high-altitude solar radiation (7,600ft+) of the SLV. This prevents "battery cooking" during the peak of summer while providing enough interior space for active heating elements during the winter.

- **Siting & Vertical Infrastructure:** To clear the 60% Fresnel zone over a 10km span and avoid signal attenuation from mature 10ft potato/barley canopies, DHUs are mounted at a minimum of **30ft Above Ground Level (AGL)**.
    - *Infrastructure Tiers:*
        1. **Grain Silos & Water Towers:** The preferred mounting points due to their extreme stability and pre-existing height.
        2. **35ft Class 4 Timber Poles:** Set 6ft-8ft deep and backfilled with crushed rock. These are utility-standard assets selected for their 40-year lifespan and inherent resistance to "wind-shimmer" (vibration that can break radio locks).
        3. **Guyed Steel Towers (Rohn 25G):** Utilized specifically for remote ridgeline bluffs to extend the "Umbrella" coverage to peripheral fields.

2. Compute Architecture & The "Black Box" Ledger

The DHU performs heavy "Data Decimation" at the edge to reduce monthly backhaul costs while maintaining a high-fidelity local record for legal auditing.

- **Edge Processing Engine:** Utilizes the **OnLogic CL210 Industrial PC** featuring an 8-Core ARM SOC.
    - *Localized Kriging:* The DHU executes localized Bayesian math worksheets provided by the Zo Server. By performing these calculations at the edge, the DHU can make instantaneous "Reflex Logic" decisions (e.g., stopping a pump if a pivot stalls) without waiting for a cloud round-trip, which is vital during cellular latency spikes.
- **The 30-Day "Black Box" Cache:** Equipped with a **128GB Swissbit PSLC Industrial SSD**. Unlike consumer-grade storage, the Swissbit PSLC (Pseudo-Single Level Cell) drive is selected for extreme write-endurance and data retention in sub-zero temperatures.
    - *Data Integrity:* It maintains a localized master ledger of all regional water transactions. If both the fiber and cellular backhauls fail, the DHU continues to record every "Audit Packet," ensuring that the farmer's water conservation credits are never lost or questioned in Water Court.
- **Atmospheric Management:** Includes dual passive Gore-Tex vents for pressure equalization. During rapid alpine storm fronts, the internal pressure must equalize to prevent the enclosure gaskets from "breathing" and sucking in the fine, abrasive alkali dust that can degrade the OnLogic cooling fins.

3. Triple-Sector Radio Spine & Resilient Power

To provide 360-degree high-bandwidth coverage across the basin, the DHU utilizes a specialized carrier-grade radio stack.

- **Sector Radio Array:** Three (3) **Ubiquiti LTU Sector Antennas (120°)**. This configuration allows the hub to handle high-bandwidth 5GHz connections while mitigating multipath interference caused by heat-shimmer and the massive metallic surfaces of center-pivot spans.
- **Redundant Backhaul Spine:**
  - *Primary:* **Fiber ONT (G-PON)** where cost-effective. Fiber eliminates the "RF-Noise" issues common in high-interference pump houses.
  - *Secondary/Failover:* **Telit ME910G1 LTE-M Modem**. Configured for "Pay-As-You-Go" IoT data, this modem only consumes data during fiber outages, keeping operational costs low while ensuring absolute connectivity.
- **Power Autonomy (7-Day Rating):**
  - *Solar:* 200W High-Tilt Rigid Mono-Solar Array designed to shed snow in under 2 hours.
  - *Battery:* **Battle Born 200Ah Heated LiFePO4 Bank**. Internal heating elements ensure the cells stay at $+5^{\circ}C$ even during $-30^{\circ}F$ "Polar Vortex" events. The system uses a "Solar First" charging priority to warm the battery before accepting charge current, preserving the 10-year battery life.
- **Lightning Defense:** Positioned at 35ft, DHUs are prime targets. Inclusion of **L-com GDT (Gas Discharge Tube) Lightning Arrestors** is non-negotiable for every antenna line.

4. Hyper-Granular DHU CapEx & Procurement (25-Unit Fleet)

This ledger reflects the civil engineering and hardware costs for the 25-hub "Umbrella" required to cover Subdistrict 1. It accounts for the varying backhaul infrastructure costs.

Category	Component Description	Supplier / Part #	Unit Cost
Computing	Industrial 8-Core ARM SOC PC	OnLogic CL210	$420.00
Storage	128GB PSLC Industrial SSD	Swissbit X-75	$185.00
Radio	120° 5GHz LTU Sector (x3)	Ubiquiti UISP	$850.00
Backhaul A	Primary Fiber ONT (Installation Avg)	Local ISP	$350.00
Backhaul B	IoT LTE-M/NB-IoT Modem (Backup)	Telit ME910G1	$115.00
Housing	NEMA 4X Polycarbonate Box	Polycase ML	$180.00
Power	200W Mono-Solar Array	Renogy	$340.00

Power	200Ah Heated LiFePO4 Bank	Battle Born	$850.00
Tower	35ft Class 4 Timber Pole (Set)	Local Utility	$1,500.00
Protection	Lightning Arrestor/Surge GDT	L-com	$125.00
TOTAL	**Per Unit Hardware Cost (Fiber Ready)**		**$4,915.00**

Subdistrict 1 Infrastructure Totals (25 Hubs):

- **Hardware Subtotal:** $122,875
- **Fiber Trenching/Drop Allowance:** $25,000 *(Estimated $1k per site for cost-effective drops)*
- **Site Foundation & Concrete:** $12,500 *(Pole footings + grounding grids)*
- **Labor (Vertical Blitz):** $18,375 *(Utility crew utilizing Auger-Bucket trucks for pole setting)*
- **DHU PROJECT TOTAL: $178,750**

5. Strategic Value & "Resolution Pop" Support

The DHU is the final staging area for the **Enterprise (1m) Resolution Tier**.

- **The Resolution Engine:** By aggregating the high-fidelity GNSS and flow data from the PMT with the subsurface pings from the LRZ mesh, the DHU facilitates the **"Resolution Pop"** in the farmer's UI.
- **The Sales Funnel:** If a user on a lower tier attempts to view 1m granular data, the DHU triggers the blurred preview funnel. This proves the value of the Enterprise subscription by demonstrating the DHU's ability to sync data in real-time, even during regional internet