IMAGE: GRANT OSWALD

SIPHONLESS LAYOUTS FACTSHEET SERIES #3

RESOURCES FOR COTTON GROWERS ON SIPHONLESS LAYOUT DESIGNS, IMPLEMENTATION AND AUTOMATED MANAGEMENT USING SMART IRRIGATION TECHNOLOGIES

CRDC COTTON RESEARCH AND DEVELOPMENT CORPORATION | CottonInfo

DEVELOPED BY SYNTIRO AGRICULTURAL SERVICES PTY LTD

Siphonless system planning and design considerations

Siphonless irrigation systems can deliver significant labour, machinery, and water efficiency gains, but only when designed and developed correctly.

ANDREW MCKAY

Figure 13: Accurate surveying is a key part of field design.

Before investing in a new layout, several key principles should be carefully assessed. This factsheet draws on designer and grower experience to highlight important planning considerations and common challenges associated with siphonless system design and development. This factsheet is part of the *Siphonless Irrigation Factsheet Series*. For background on siphonless systems and their benefits, see *Factsheet 1: Introducing Siphonless Systems*. For a detailed description of siphonless system types, see *Factsheet 2: Types of Siphonless Systems*. For construction and commissioning guidance, see *Factsheet 4: Siphonless System Development*. See the *Case study on Tailwater Backup and Inlet spacing* for worked example of design impact.

PRE PLANNING PREPARATION

Visit siphonless systems

» Growers should visit siphonless systems in their district, ideally spending a full day during irrigation operation to gain an understanding of how the system functions.

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Select a designer

- A qualified engineer with detailed irrigation experience or a qualified surveyor with additional training in irrigation engineering are good options. Their technical experience is critical for identifying site-specific constraints and achieving an effective design. Request references and inspect completed projects.

Define expected outcomes

- Clearly define issues with your existing system to determine whether siphonless conversion is the best solution, or if lower-cost modifications to your existing system might suffice (see WATERpak Chapter

SITE ASSESSMENT

A site assessment identifies physical constraints that determine system suitability, design requirements and development costs. The following factors should be considered during the site assessment and development planning.

Topography

- Accurate topographic survey using RTK GPS is essential for good design and efficient cost management of the project. Designs should work with natural slopes where possible to avoid expensive earthworks and topsoil removal. Survey must include existing supply water levels, tailwater outlets, and recycling system elevations to establish limiting factors for system design. Slopes steeper than 0.300% (1:333) are unsuitable for siphonless systems due to erosion risk.

Soil characteristics and infiltration

- Infiltration rates determine suitable run times. A basic understanding of infiltration can be estimated by observing how many minutes it takes for the profile to refill from the moisture probe data. Achieving optimal run times is discussed in detail in WATERpak 5
- Level basin systems suit hard setting and poor subbing soils that require extended inundation.
- Sandy areas with excessive infiltration may not be suitable for irrigation development.
- Soils prone to slumping or erosion require careful assessment, as high flows can cut into the side of beds.
- Topsoil depth varies across fields and must be assessed. Large cuts expose infertile subsoil, causing yield losses for years to come. Knowing tolerance for cut depth before yield is reduced is essential for planning earthworks. Refer to a recent EM survey and conduct soil tests to identify soil variability and problem areas.

Water supply and flow rate

- High flows are essential for uniform water delivery. Available flow dictates bay dimensions, infrastructure sizing, and system suitability. Quantify total available flow from all sources. Many siphonless systems require flows that exceed that of a single bore or small scheme offtake structure. In some regions, delivery entitlement during peak demand periods may limit available flow rate and must be factored into available flow. Evaluate the existing supply channel capacity to ensure bottlenecks don't occur. Ensure pumping and tailwater recycling system can handle flows (particularly for PTB systems with high tailwater volumes).

DESIGN PRINCIPLES

Design decisions determine long-term system performance, future expansion capability and economic viability.

Whole farm planning: staged development and future proofing

- Converting a single field or section of field to siphonless provides valuable operational experience before committing to whole-farm development. Initial conversion is often undertaken on fields with challenging characteristics such as difficult soil types, sharp point rows, or insufficient head for siphon operation.
- Following successful operation of the initial field, develop a whole-farm plan to guide subsequent stages and ensure the size of supply channels, tail drains and recycling systems are sufficient for the ultimate flow when all fields are converted.
- Future automation should also be factored in (see Infrastructure and bay sizing section).

Waterlogging prevention and drainage

Waterlogging is one of the most significant yield-limiting factors. It is best prevented by careful planning at design stage, as it is costly to rectify once the wrong system is established. Waterlogging and poor drainage in fields restricts

normal root activities and can lead to increased severity of plant diseases such as verticillium wilt and root rot. Drainage planning, including accounting for slope, furrow length and tailwater drainage capacity, must be integral to design.

Infrastructure and bay sizing

» Outlets, channels and tail drains must handle peak accumulated flows plus a safety margin of 10–20% above calculated peak flows. Note that flow rates accumulate in bay systems as tailwater from preceding bays adds to new supply water, requiring larger infrastructure capacity downstream.
» Larger bay sizes require higher flows but reduce the number of outlet structures required. This can reduce capital costs, particularly if considering investment in smart irrigation and automation devices.
» Consult with service providers before finalising design to ensure outlet and drive mechanisms are compatible.
» Keep designs within proven parameters.
» Oversizing level basins can cause waterlogging.

Cropping program

System design should align with intended crop rotations and machinery configurations. Consider the following:

- *Crop frequency:* how often irrigated crops are grown in the field and in-season irrigation frequency affects return on investment and system selection.
- *Row spacing and machinery compatibility:* row spacing, tractor and implement width, and spray rig width must be compatible with the chosen system design. Consider if there are intentions to change any of these.
- *Rice integration:* level basin systems suit rice-cotton systems due to their ability to pond water.

Minimising earthworks

» Earthworks volumes differ between layouts, directly affecting development costs. Designs minimising soil movement will protect productive topsoil and reduce costs (see Soil characteristics section).

FINANCIAL ASSESSMENT

Development costs are substantial and vary significantly between system types. This assessment can only be made once all technical requirements and constraints are understood.

» Available cashflow or financing capacity must be adequate. Down the slope conversions typically require less capital outlay than Level Basin systems due to reduced earthworks. Preliminary design proposals should include comprehensive budget estimates. Evaluate potential savings in labour, pumping, travel, and management time alongside capital costs. Consider long-term factors such as labour availability, water reliability, and energy costs.

CONCLUSION

Taking time to assess site constraints, evaluate financial costs, and engaging an experienced designer before committing to development reduces the risk of costly development mistakes. For tips on successful construction and commissioning, see *Factsheet 4: Siphonless System Development.*

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Table 3: Siphonless design consultants

Footnotes

[1] Small PTBs still require two-meter rotobucks. Whilst offering labour saving benefits, they retain most similarities to manual hand siphon systems and therefore are excluded from general siphonless system comparisons in this guide.

[2] Siphonless irrigation guide. Smarter Irrigation for Profit, 2019.

[3] Grower Case Study 'Norwood' Moree. CottonInfo, 2024.

[4] Siphonless irrigation guide. Smarter Irrigation for Profit, 2019.

[5] Siphonless irrigation guide. Smarter Irrigation for Profit, 2019.

[6] Siphonless irrigation guide. Smarter Irrigation for Profit, 2019.

[7] Irrigation systems, designs and scheduling options. GVIA. 2022.

[8] Grower Case Study 'Norwood' Moree. CottonInfo, 2024.

[9] Bankless channels- Bullamon Plains. More Profit Per Drop. 2011.

[10] WATERpak a guide for irrigation management in cotton and grain farming systems. CRDC. 2012.

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Matt Champness led the project and developed the smart irrigation content, with review and editing of siphonless system design content. **Harriet Brickhill** developed the siphonless systems content and provided review and editing of smart irrigation technologies content. **Glenn Lyons** provided technical input and review of siphonless system content.

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GLOSSARY

Naming conventions differ between regions and have changed as systems have evolved. Where multiple terms exist, bold text indicates terminology used within this document.

API (Application Programming Interface): A set of rules and protocols that allows different software applications to communicate with each other. In smart irrigation, APIs enable sensors from different manufacturers to share data with control platforms.

Automated Irrigation: Systems where the decisions about when to open/close inlets/ outlets or start/stop pumps are made automatically by the supervisory system based on sensor data and programmed rules, without requiring human intervention for each action.

Bay: A section of a down the slope field that is separated by banks running from supply end to tail drain.

Basin: A section of a field where there is no or minimal slope along the furrow, that is separated by banks running from end to end.

Bankless Channel/bankless head ditch: Used in GL Bays & Basin systems. A below field height levelled area that is filled prior to water entering furrows. It acts as the supply and drain. Drainage is through a check structure into the next stepped bay or basin.

Bankless Side Channel: Used in Rollover Bankless. A below field height channel that runs in the same direction as the furrow and supplies water to a bankless channel at each end of the furrow.

Bankless Check: Drop board, rubber door or gated pipe that controls the passage of supply water from bay to bay – or basin to basin.

Command: An instruction sent from the supervisory system or user interface to a controller, directing it to perform an action (e.g., open outlet, close valve, start pump).

Communication Network: The connectivity layer that transmits data and commands between field devices (controllers & sensors) and the supervisory system. May use cellular, LoRaWAN, radio, or Wi-Fi.

Controller: A device that opens and closes irrigation infrastructure (inlets, outlets, valves) based on commands from the supervisory system or direct user input. May include motor/actuator mechanisms and control electronics.

Cross Fall: lateral slope across the field (as opposed to down the slope of the furrow).

Dispersion Pond/ distribution basin / distribution bay/ dispersion basin/ pontoon area: Used in PTB systems. Below field height levelled area between head ditch and furrows that is filled prior to water entering furrows. This is only a supply and is at the upper end of the field.

Gateway: A device that receives data from field sensors or controllers using one communication protocol and translates it for transmission to the supervisory system using another protocol. Common in LoRaWAN and radio networks.

GL Bays: A siphonless system consisting of terraced bays stepping down the landscape with furrows running perpendicular to the natural slope. Water is supplied via bankless channels, with tailwater reused between adjacent bays.

Handshake: A communication protocol where the receiving device confirms it has received and executed a command. Provides verification that actions have been completed successfully.

Head Ditch: The main supply channel for the field, which enables supply via manual hand siphons, small pipe through bank or large pipe through bank. This controls water head height.

Level Basin/ flat bays, flat flat, beds in bays, bankless channel: A siphonless basin system with zero or minimal slope (typically flat or 0.01% down slope) along furrow length. Water enters and drains through bankless channels at each end of the furrows. Field is divided into terraced basins stepping down the landscape.

LoRaWAN (Long Range Wide Area Network): A low-power, long-range wireless communication protocol designed for IoT devices. Requires a LoRa gateway on the farm and is well-suited for large farms with many distributed sensors and controllers.

Offtake: Primary point of delivery from the irrigation scheme/river.

Outlet: An overarching term for a structure used in irrigation systems to control the flow of water. Includes inlets and check structures.

Pipe through Bank (PTB)/ Large PTB, Pontoon: A siphonless system where large diameter gated pipes (250-750mm) are installed through the head ditch bank to deliver water to a dispersion pond. Water then flows simultaneously into multiple furrows (typically 12-96 furrows per pipe). Field slopes down to taildrain.

Platform: The software system (web-based or app-based) that provides the user interface for monitoring and controlling smart irrigation equipment. May include data visualization, scheduling tools, and alert management.

Protocol: A set of rules defining how data is transmitted between devices in a communication network. Different protocols (e.g., LoRaWAN, Modbus, MQTT) have different characteristics for range, power consumption, and data capacity.

Radio (RF): Short-range wireless communication between nearby devices using radio frequency signals. Typically requires line-of-sight and may use mesh networks where devices relay signals to extend range.

Remote Irrigation Control: Irrigation systems where human operators make decisions about when to irrigate and manually trigger actions (open/close outlets, start/stop pumps) through a remote interface (app or web platform), without travelling to the field. Differs from automation where the system makes decisions.

Repeater: A device that receives and retransmits signals to extend the communication range of a wireless network, particularly important for large farms or areas with terrain obstacles.

Rollover / Rollover Bankless: A siphonless basin system where furrows follow the natural slope direction (allowing machinery to "rollover" from one basin to the next). Requires very flat terrain (<0.04% slope). Uses bankless side channel and bankless channels for water supply and drainage.

Sensor: A device that measures physical parameters (water height, soil moisture, weather conditions, flow rate) and transmits data to the supervisory system to inform irrigation decisions.

Sill: The point in the bay where the field slope changes to a negative slope.

Siphonless Irrigation: Surface irrigation systems that deliver water at high flow rates from an inlet to a below-field-level area where water spreads evenly before entering all furrows simultaneously, eliminating the need for hand-placed siphons and 2-meter rotobucks.

Smart Irrigation: An umbrella term for advanced irrigation technologies that use real-time data and automation to optimise irrigation management. Includes sensing/monitoring, remote control, and automated irrigation systems.

Small Pipe Through the Bank (Small PTB): A system using permanent 75-90mm pipes installed through the head ditch at consistent levels. Still requires 2m rotobucks. Variations include stepped set, double head ditch, and smart siphon configurations. See Chapter 1, Section 4 for detailed descriptions

Supervisory System: The central control or decision-making system that processes sensor data, interprets field conditions, and triggers controller actions (opening or closing infrastructure).

Supply Channel: A channel that carries water throughout the farm to supply the head ditch or fields.

Supply Inlet: a structure that allows water to enter the system, usually from the supply channel

Tail drain: Tail drains remove run-off from the field created by both irrigation and rainfall events.

Tail drain Checks: Drop board, rubber door or gated pipe that controls the passage of tailwater from bay to bay.

Tail drain Outlet: Drop structure and pipe that passes the tailwater to the recycling system.

Tailwater Backup (TWB): The slope at the tail drain end of the field is reduced to allow tailwater to back up slower furrows. This backed-up water is then drained and reused in the subsequent bay.

Terraced Basin: A basin system configuration where basins step down the landscape with minimum 15cm vertical drop between each basin level. Used in both Level Basin and Rollover systems.

Time-based Controller: A controller that operates on pre-programmed time schedules to open/close infrastructure or start/stop pumps. May lack sensor feedback beyond basic fail-safe protection.

User Interface: The platform (local buttons/screen, Bluetooth connection, mobile app, or web portal) where operators monitor system status, view data, and control irrigation equipment manually or remotely.

For further information:

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