Breaking Design Barriers:

iCAD Software's Revolution in Irrigation Projects Development

White Paper, Apr 2024.

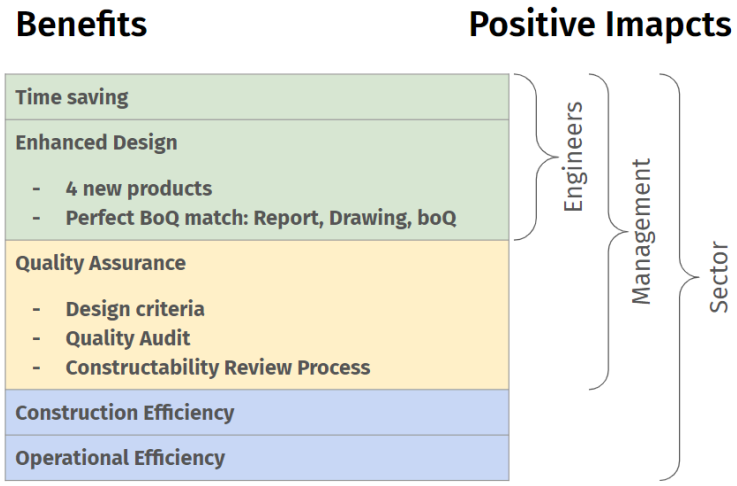
iCAD[1] software is an innovative solution to the long standing design challenges in the irrigation development sector. Traditional methods of analysis, design and documentation lack accuracy, detail and overall quality. As a result returns from investments on projects are meager, and the agriculture sector has a long way to go.

iCAD demolishes the barriers to 'good design' practices, leveraging advanced computational technology and digital tools. The products is a complete solution, including:

- Supply Canal networks and structures
- Drainage canal networks and structures
- Headworks and appurtenant structures

An operational simulation component to be included towards the end of our partnership with EEC will make the products a truly all-in-one solution for the sector, serving needs end to end.

From the beginning, we strongly believed the product was for Engineers. Very quickly though, we have seen evidence that this is more than an engineer's tool, adding value to project managers and clients. Now, we are even more strongly convinced that with scale, iCAD can revolutionize Ethiopia's irrigation sector at large.



In this document we present the evidence for our bold claim: "Breaking Design Barriers: transforming Ethiopia's irrigation development sub-sector" via:.

Accurate BoQ ❋ Cost Optimization ❋ Enhanced Design Quality
New Design Standards ❋ Design Quality Assurance ❋ Operational Simulation

[1] iCAD is also a family of products - including CanalNETWOR, DrainNETWORK, and OPSIM.

Accurate BoQ

Conventional design methods rely on 2D profile data extracted along the centerline of a canal to determine design levels and resulting quantities. It assumes that there is no lateral variation of ground level.

iCAD software, however, leverages surface reconstruction and data processing algorithms that can achieve significant levels of accuracy in quantity estimation. Among the validation and case study works done in this regard, the case of Dabus Irrigation project is one.

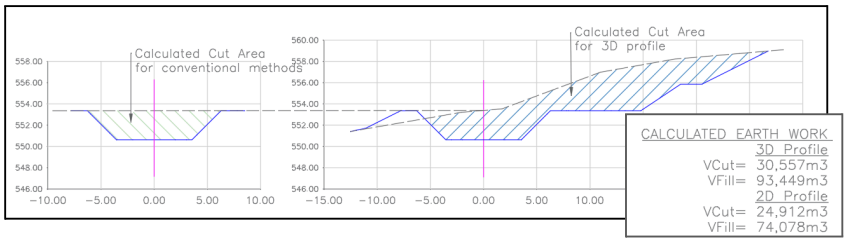
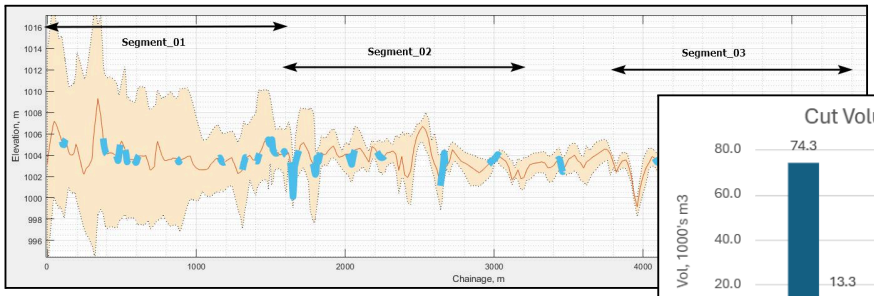
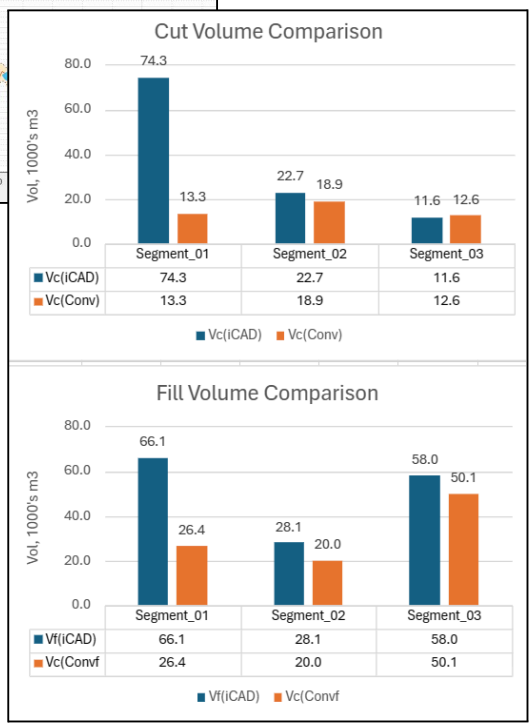


Figure: Sharp contrast in consideration of terrain data for conventional (left) and iCAD (right) methods.

Dabus Case study has established that the conventional method underestimates volumes, as it misses out important terrain details. The errors are significant in segment 0. Here lateral terrain variation is also significant. The results of the conventional method represent only less than 20% and 40% of the expected volume in fill and in cut respectively.





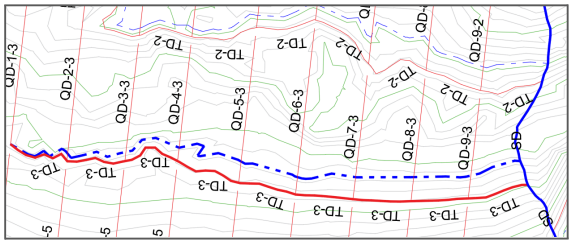
iCAD tools can use very high resolutions for profile data (up to 0.5m) for even higher levels of accuracy - provided sufficient data is available.

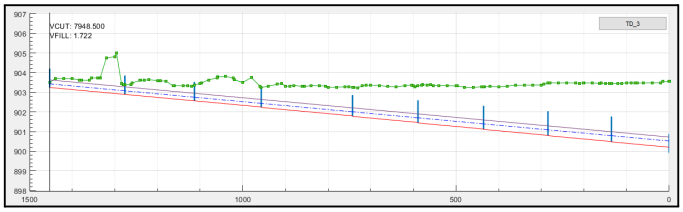
These errors are contributing factors to poor budgeting, bidding complications, and excessive variation claims during construction.

Working with iCAD software can reduce the prevalence and magnitude of these problems during design, bidding and construction.

Cost Optimization

Conventional methods for canal alignment rely heavily on expert judgment. Often, the engineer creates alignment vertices roughly between two successive contour lines, while also attempting to achieve a conducive grade for water flow - a task easier said than done. Because the task is tedious, engineers will not have the time (and patience) to experiment with various alignments to optimize cost.





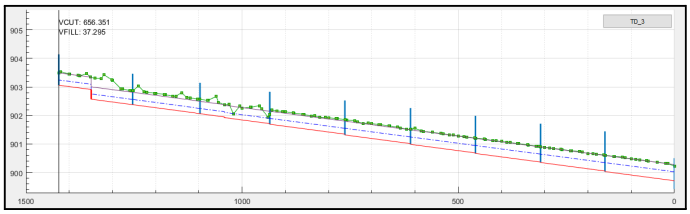
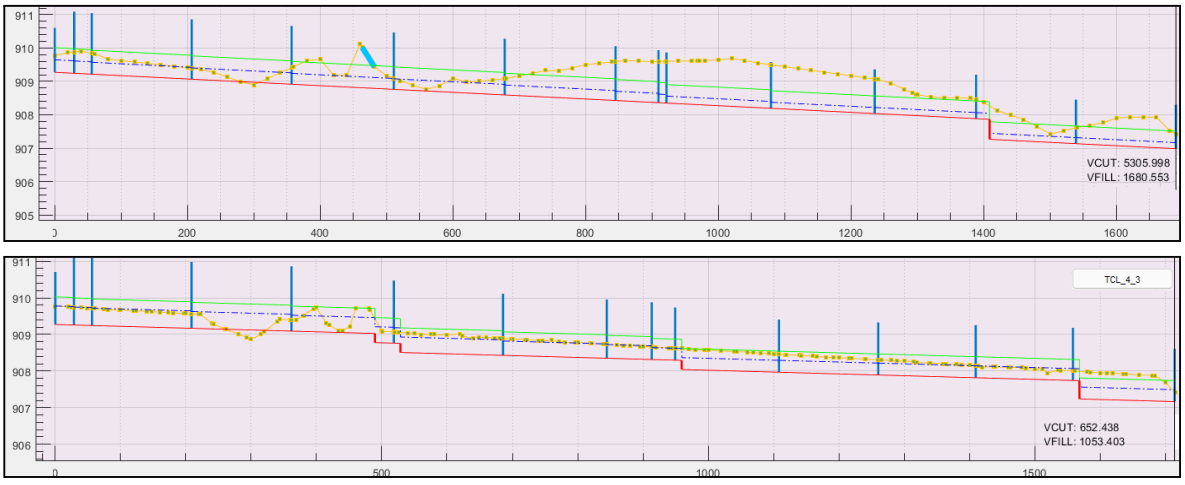


Figure: Canal Alignments created manually (Blue, broken line) and Gradeline Search tool (Red).

iCAD presents an easy to use and fast gradient search tool to achieve this task. For the drainage canal TD-3, the alignment created with iCAD's gradient search tool gives the best and optimized alignment for the canal. A comparison of quantities for four tertiary drains shows, iCAD's alignment gives 85% less earth work compared to that of the manual method.

A similar exercise on a supply canal block shows, iCAD's alignment can reduce 82% and 50% of cut and fill works. The cost savings when applied on entire projects can be substantial.



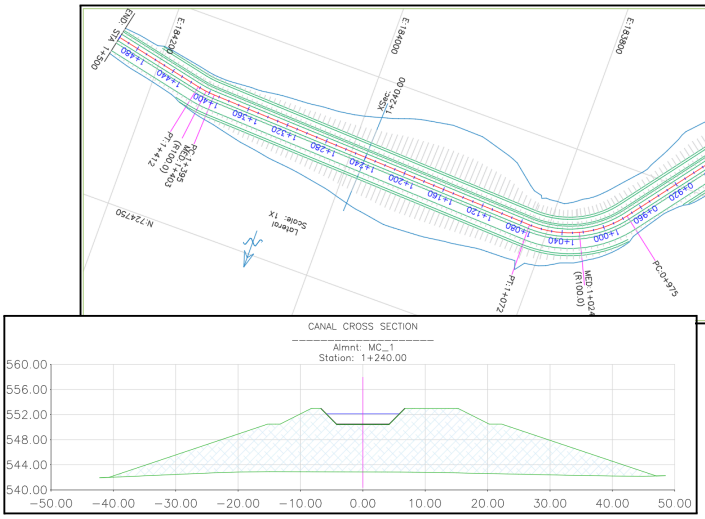
iCAD's tool allows engineers to plan and design cost-effective structures with substantial cost saving, which can meaningfully reduce the cost of irrigation projects at large.

Enhanced Documentation Quality

Complete and accurate documentation constitutes an important pillar of Quality. Conventional tools, methods and processes utilize heavily manual approaches to documenting design products. As a result errors are unavoidable. Limited drawings can be generated. Quantity items, being quite an extensive list, miss items here and there. In addition quantity estimates are manually collected from different excel sheets opening room for more errors.

iCAD's architecture is built on the Design-Draw-Estimate philosophy - allowing engineers to print or draw what they have designed without the need for additional processing. This bridges the gaps between design and production, allowing for consistent output production. Automated drawing generation and quantity listing, means zero room for missing items and introducing errors.

Figure: Automatically generated BoQ listing for a canal network; Accurate plan and section views generated to AutoACAD..



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Schedule of quantities (BoQ)

Chapter . Schedule of quantities (BoQ)

Schedule of estimated quantities of works for host Object described as:

- MULTIPLE CANAL ROUTES

Please note the following Abreviations:

WBS: Work Breakdown Structure
UoM: Unit of Measure
Qty: Estimated value of quantity
m^2: Square meters
m^3: Cubic meters
Lm : Linear meters

WBS	Description	UoM	Qty
3	CANAL ROUTE: QC_6B_2_5 *CADId47A*		
3.1	Canal(1):-Canal alignment STA: 0+000.00 To 0+934.12		
3.1.1	Earth Works		
3.1.1.1	Excavation of of existing formation to designed Canal Bed Level or foundation level ing, per design specifications	m^3	146.427
	vay of excavated material to a a to a distance of **00**KM	m^3	175.712
	isting formation to a depth of Ms* between RoW distances	m^2	2863.918
	cleared existing formation to level corresponding to Canal of foundation level, as applys sign schedule; and adequately mpacted as per specifications.	m^3	520.634
	re at chainage 47.306m nd exit protection work that not included		
	Earth Works		
	xcavation to designated depth	m^3	19.811
	Finishing works		
6.35.1.3.1	*Pointing/Lean concrete* lining for inletor approach channel	m^2	3.220
6.35.1.3.2	ditto but for exit channel	m^2	3.220
6.35.1.3.3	ditto for stilling basin walls and bottom	m^2	1.768

* End of Listing

Most projects suffer from inconsistencies in documentation, which costs clients significantly in time and resources. Such issues are also causes of inefficiency and delay during construction.

iCAD has introduced and established a new and superior documentation standard - that can bridge document scope and accuracy gaps in the sector.

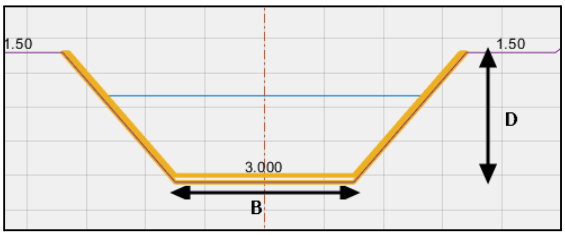
New Design Standards:

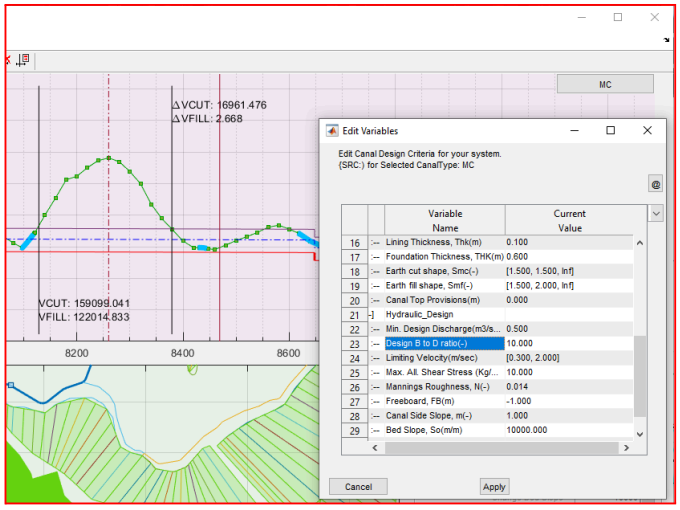
Challenging the B/D Ratio

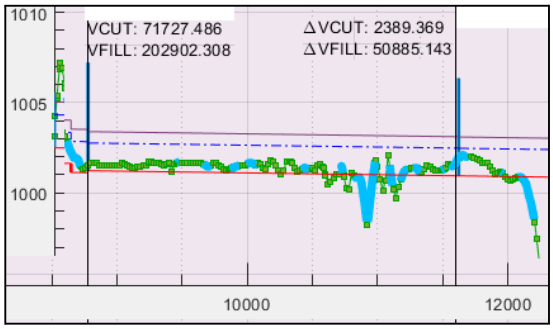
Manning's equation is widely used to determine the size of canals to carry a specific amount of water flow. The flow area A and perimeter P depend on the dimensions of the canal *b* and d, for known m and S values. References establish recommended B/D ratio values as a function of discharge, Q, and between 1 and 10.

$$Q = \frac{1}{n} A^{2/3} P^{5/3} \sqrt{S}$$

Adopting these ratios, as is, without local research feels like a gamble. Using iCAD tools, we investigated what the impacts of using different B/D ratios would be on project cost - a key measure of feasibility.







While investigations continue with case studies and research projects in collaboration with partners, the initial findings are eye opening.

A 250 meter canal carrying 3.7m3/sec, and about 3 KM long canal carrying 2.9m3/sec was analyzed. We now understand that - all canal performance measures maintained - using a small B/D ratio can reduce costs for canals in cut. For canals in fill, using a high B/D ratio can reduce costs.

For this exercise, we found 43% and 33% cost savings are possible.

iCAD software has enabled engineers to challenge conventional approaches and practices that are often taken from other countries. In addition to revealing action research areas, this opens new opportunities to explore additional ways for substantial cost saving in project formulation.

Design Quality Assurance

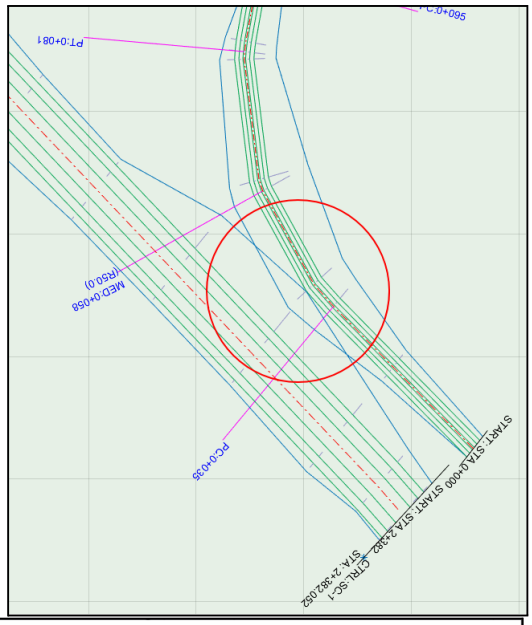
In modern practices, quality is an integral part of processes. Heavily manual and traditional design tools have made it challenging for the sector to follow suit. aDesigns take too much time and effort to complete. Design verification and quality assurance is equally demanding and cumbersome task, and -as a result - least practiced. The tools in use have severe computational limitations for the job.

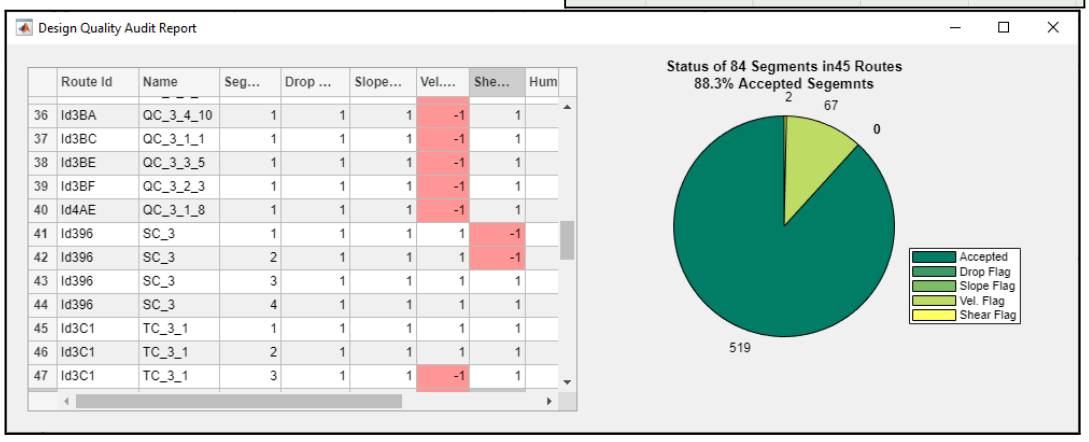
iCAD has allowed new and efficient ways to ensure designs meet operational and constructability requirements.

- Criteria based design workflow automatically executes designs per set criteria. Users can override these values, but can later follow up.

- Advanced visualization tools help engineers view as built conditions and tackle potential constructability issues early in the design process. On the right is an alignment issue that calls for extensive design review, only detected using the software tools.

- Design Quality Audit is a newly introduced speciality tool. It can analyze all canals for unmet performance/construction requirements and identify them for faster and complete resolution.



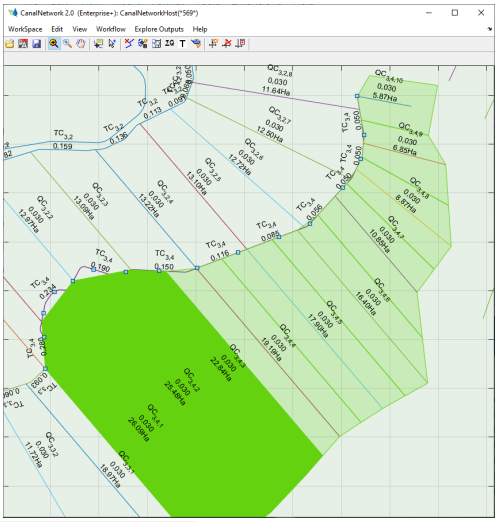


These quality assurance tasks are extremely challenging, if even possible, for conventionally designed projects.

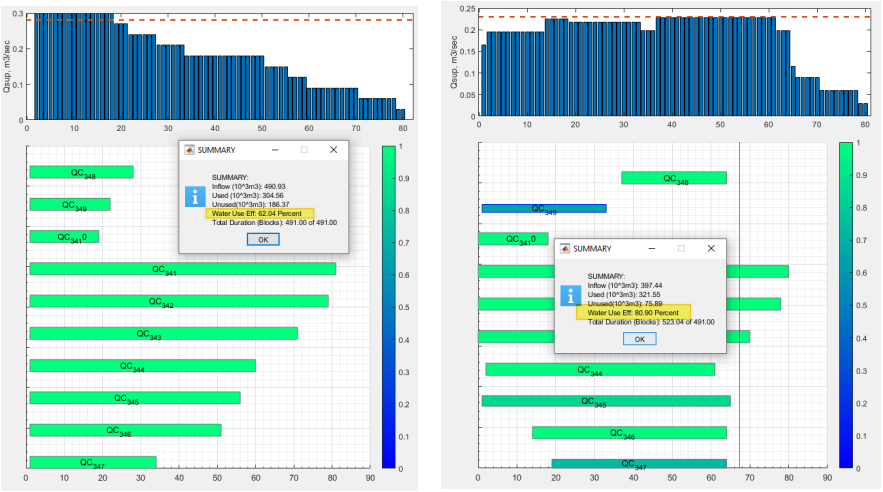
iCAD products offer the means to achieve quality assurance with speed and accuracy - in a whole new way, and for the first time!

Operational Simulation - A New Frontier

During design, one of the least talked about topics is operation. Despite all the emphasis in research and standards, there is little practical consideration of how designs impact operational conditions. The lack of accessible and rapid modeling tool is a contributing factor.



A new tool is evolving to aid engineers understanding operational schedules, and how canal sizes are impacted as the schedules are changed. Initial learnings show stark contrast to *'common practice'* knowledge. Rotational irrigation (not shown) can take extended time with unmanageably small discharges. Continuous irrigation can be difficult to manage. In terms of water distribution, both methods can have substantial levels of inefficiency compared to optimized water delivery schedules.



Figures: A Tertiary block with individual farm blocks (above), water distribution schedule and estimated water used by quaternaries - continuous (left), and optimized (right).

Optimized distribution schedules may also lead to reduced design capacity on tertiary canals - which can reduce construction costs.

The introduction of such tools, and their enhancement to suit operational contexts specific to water use practices in Ethiopia can be indispensable in transforming the design and operation practice. The total lack of concern to operational aspects in today's design practice may explain some key challenges faced by operators and farmers.

We are actively seeking partnerships with key industry and academic actors in the sector, towards further developing the tool and validating its potential for impact towards a transformed irrigation sector.