Irrigation Construction Management:

Capital Projects Irrigation Design and Installation Quality Control

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Overview

Intense scrutiny of irrigation, landscaping and related subject matter during the entire Capital Projects planning and construction cycle is a vital component of the University of Washington's (UW) Landscape Irrigation Water Conservation Program. The goal of this paper is to empower irrigation and landscape workers, and enlighten planners, managers, policy makers, designers, and project personnel, with a critical aspect of irrigation water conservation: Irrigation Construction Management – Capital Projects Irrigation Design and Installation Quality Control.

Background Information

The UW is the top water user in the Seattle Public Utilities District. Of the UW's 700 acres, 54 are ornamental landscapes and athletic fields serviced by over 100 automatic irrigation systems, close to 1000 valves, over 6 miles of subsurface drip, and about 13,000 sprinkler heads and rotors. About forty percent of the systems are centrally controlled and include water conservation and control features.[1] On average, the Seattle area requires 15 inches of supplemental water per summer.

Irrigation is a small slice of the UW pie, but is significant, nonetheless, in supporting the amazing blend of structure and landscape for which the UW is renown. Landscapes surround buildings, are on buildings, in courtyards within buildings, border the many connecting paths and roads, and frame the open spaces and campus perimeter.

This blend, indeed, is a relevant component to the greater mix that is the UW – excellence in academics, research, medical services, libraries, arts, galleries and museums, park-like grounds and horticultural center, a lecture and conference venue, a collegiate/professional sports and athletics facility, and a public sports and entertainment complex.

The combination of architecture and landscape provides a healthy, soothing, and exhilarating experience for students, faculty, staff, the surrounding community and visitors. It is the job of UW Irrigation to support the slice of the pie that is a part of the aforementioned mix.

With a limited staff, dramatic growth,[2] and an increasing need for water conservation, we have no choice but to be efficient and effective operationally to ensure efficient and effective water conservation. Design and installation quality control is but one of many responsibilities comprising the duties of the UW Irrigation Specialist.[3] Thus, balancing the construction management function with the other responsibilities is indeed challenging.

Why Is Design and Installation Quality Control Important?

Ensuring sound designs and quality installations directly contributes to water conservation. These are the first steps and essential elements for new irrigation water conservation efficiency and effectiveness.

Both proper selection and correct installation of products with respect to plant water requirements and microclimate variables[4] are key to irrigation water conservation. Quality designs and installations significantly minimize costly Change Orders, minimize rework, reduce future maintenance costs, and contribute to system longevity.

If we get the opposite, countless hours often go to correcting poor designs and installations. Not only is there poor water conservation, poor plant health, rework, reduced goodwill from the ever observant public, and reduced aesthetics during the interim, but there is the opportunity cost of the time and resources that could have been used for the maintenance, alteration, and improvement of other irrigation systems.

Elements of a Successful Installation

- Quality design, product and installation information
- Quality construction documents
- Quality execution of plans via irrigation construction management

Design, Product and Installation Information

The UW Facilities Design Information (FDI) for Irrigation is given to irrigation designers and landscape architects early in a project. The FDI is a set of design, product and installation specifications and details. The FDI for Irrigation is updated annually by UW Irrigation and UW Engineering.

The idea is simple – quality input parameters improve the likelihood of quality output.

The UW Capital Projects Planning and Construction Cycle, Entities, Players, and Procedures

The UW Capital Projects planning and construction cycle is organized by strictly defined phases, steps, and procedures. It consists of the following phases: Programming/Pre-Design, Schematic, Design Development and Construction Documents, Installation, and the Warranty Period.

From an irrigation perspective, the following UW entities and players are involved: Capital Projects (Project Manager, Construction Manager, Construction Coordinator, Campus Landscape Architect); Engineering Services (Mechanical, Utility, and Other Engineers); Design Services (CAD); and Shops (Grounds, Irrigation, Plumbing, Electrical, Computing & Communications, Control Technicians, Heavy Equipment, Utilities, Masons, and Roofers).

The following outside/contracted entities and players are involved: General Contractors, Subcontractors (Landscape/Irrigation, Demolition and Earthwork, Utilities), Landscape Designers, Landscape Architects, Engineers, Consultants, Seattle Public Utilities, Manufacturers/Technical Support, and Suppliers.

Irrigation construction management is challenging. It requires that the Irrigation Specialist learn the construction phases, procedures, protocols, and terminology used by project personnel. The specialist must interface appropriately, via emails and attachments, blueprints and details, typed punch lists, digital photos, written documents and renderings, faxes, scheduled and unscheduled meetings, and cell phone calls while in the field.

The following outline identifies the main project phases (boldface) and associated procedures.

Programming/Pre-Design: scope assessment; FDI to landscape architects & irrigation designers
Schematic: simple layout of irrigated landscape areas; general plant types
Design Development and Construction Documents: details, specifics, major problems solved

- Respond to Requests for Information (RFI) (e.g. existing field conditions, As-Built Drawings)
- Document Review
    - Irrigation, Landscape, and to a lesser extent, Electrical, Telecommunications, Demolition, Drainage, Earthwork, Utilities, and Field Furnishings
    - Final Comment Resolution: formal recommendations and feedback for alternative designs, products, and specifications via the Project Manager
    - Document Sets: Permit, Contract, and Construction Documents

Installation

- Pre-Construction Conference (general/overall project scope): Construction Schedule, meetings, procedures, coordination issues, Q&A, troubleshooting and problem solving
- Pre-Installation Meeting (for each discipline): introduction of General Contractor and Landscape/Irrigation Subcontractor; review Product Submittal; discuss Construction Schedule, phasing, and coordination issues; discuss scope of work, red-flags, non-entitlement (no cost) adjustments, and entitlement (additional cost) Change Orders
- Weekly Progress Review/Site Inspection Meetings: review installation work and As-Built Drawings; troubleshoot field problems and design anomalies; document work (e.g. prepare Site Observation Reports with corrective work punch lists, print notation, digital photo support, field notation via paint and marking flags).

- Random Site Inspections: periodic site visits to monitor and inspect installation quality control and troubleshoot problems
- Crisis Meetings: often necessary to deal with time sensitive and/or entitlement issues
- Consult, review, and inspect Architectural Supplemental Information (ASI) and Change Order Proposals (COP)
- Performance Testing: formal testing of key irrigation system components
  - Mainline and lateral line static pressure
  - Coverage and working pressure – adjust primary and zone pressure regulating valves
  - Electronic valve operation via controller, remote and central control
  - Master valve, flow sensor, and moisture sensor operation via controller and central control
  - Communications Loop Testing for Central Control
- Performance Testing Activities
  - Pressure Testing: ongoing as construction permits
  - Pre-walk: this site inspection is conducted unilaterally by UW Irrigation prior to the Preliminary and Final Punch Lists. This offers more thorough findings and better preparation for formal site inspections
  - Preliminary Punch List: formal meeting and site inspection procedure to identify installation and design problems, and to determine corrective actions
  - Final Punch List: formal meeting and site inspection procedure to identify status of Preliminary Punch List and other corrective work. When the contractor has satisfied these obligations, the status of Substantial Completion is granted, initiating the warranty period and final payment to the contractor.

Warranty: ensure product, installation, and plant quality for a specified warranty period (one or two years) started at Substantial Completion; follow-through on problems

<u>Access, Reality of the Construction Cycle, Engaging the People and Process</u>

In-depth project involvement is often not available to irrigation specialists, but should be, as a means of adding value to projects by increasing success in terms of promoting quality irrigation and landscape design and installation with respect to water conservation.

In addition to the difficulties presented by lack of access, the typical position of landscape and irrigation work at the end of the construction cycle can result in problems. For examples:

- Contingency budgets are often depleted; thus, additional dollars for landscape and irrigation needs are not available
- The backlog of other project activities can result in the compression of work at the end of the cycle, especially considering firm completion deadlines; thus, the lack of time, stumbling over others, and the pressure to meet deadlines can decrease quality
- The project entities and players may be tired at this stage of the game; thus, don't have comparable energy or interest in addressing landscape and irrigation issues
- Project personnel are often preoccupied with completion and moving onto the next project; thus, important details tend to get pushed under the rug

Activities for successfully engaging the people and process follow.

- Preparation; comprehension of design info, construction documents and procedures
- Develop quality support materials (e.g. design information, details, product and performance specifications, punch list format)
- Have confidence in one's expertise; facilitate interpretation of irrigation issues in layperson terms
- Get funding for consulting and inspection work
- Follow procedures
- Manage multiple projects, at various stages, simultaneously
- Understand the politics unique to each project; develop and cultivate relationships; assertiveness; picking and choosing battles; professionalism; compromising; teamwork
- Meet deadlines; follow through with commitments; consistency; cope with deadline pressure
- Documentation and record keeping; prepare and present information
- Anticipate problems and develop solution alternatives; be proactive
- Willingness to get "bloody noses;" learn from mistakes
- Earn trust of project personnel; get limited non-entitlement decision making authority

Examples of Project Installation Problems: ICA Indoor Practice Facility (OPF Phase 1), Project 2498

For digital photos – Figures 1 through 8, please see below. The photos were taken in the spring of 2001; the installation occurred in the summer of 2000. All of the following project photos illustrate improper installations that result in poor water conservation. In addition to wasted water, the contractor incurred corrective time and materials costs, not to mention looking bad excavating some 128 heads and swing assemblies. And of course, we all looked bad. UW Irrigation was not "invited" to inspect this installation until after back filling. A lateral static pressure test was not performed prior to back filling. The project had been put on a "fast track" with NFL and NCAA football dates approaching in the adjacent Husky Stadium.

The following leakage problem was discovered during the spring 2001 system activation and pre-audit. Figures 1 and 2 show leakage from both upstream and downstream connections between fittings and polyethylene piping. The polyethylene piping was defective – pitted and incapable of making a seal. The piping also exceeded specified depths and run lengths. Furthermore, the upstream connection lacked a Marlex ell to give 3-way directional control. The resulting "bend" stress and the lack of Teflon tape further aggravated already poor connections, further contributing to leakage. Each bad swing assembly resulted in about 50 ounces of leakage per minute. Note that the worst leakage from the upstream connections was far below the root zones of the planting, thus, this water, more than half of the total leakage, was completely wasted. Note that this deep leakage was not obvious. Downstream swing assembly leaks can often result in undermining the stability, and thus pitch and elevation, of sprinkler heads over time, which typically results in high maintenance costs to "true" numerous heads during spring system activation and pre-audits. Given a Northwest irrigation season (6 months), had the leaks not been corrected, the collective leaks, considering an irrigation schedule adjusted monthly for ET, would have amounted to 317.34 hundreds of cubic feet (CCF), and at the commercial peak rate of $2.75/CCF, would have equaled $872.69 per year. Through the 2002 irrigation season, 772.66 CCF would have been lost, amounting to $2,124.82.[5]

Figure 3 shows a sprinkler head that was not installed per spec. The spec notes that heads must be installed at a grade perpendicular to the average slope. This head, despite the nozzle's 23-degree trajectory, cannot achieve head-to-head coverage with its not-in-picture counterpart to the right. This resulted in a lack of coverage/poor distribution uniformity – areas that were too wet and too dry, resulting in unhealthy and unsightly turf grass.

Figure 4 shows an improperly installed valve box. The box is above grade, and would likely impede and/or get damaged by mowing. Note the valve was installed too high, and that reinforcing cells on the underside of the lid have been cut out to make room for it, thus, weakening the lid, as well as putting pressure on the solenoid as in the case of equipment driven over the box.

Figure 5 shows a rotary sprinkler head installed incorrectly – it is too high and too close to the extruded curb. It should be flush with finish grade with placement starting at 1¼ to 1½-inches perpendicular from the hardscape. This is a likely candidate for mowing and/or edging damage.

Figure 6 shows another improperly installed valve box. Note that it's resting on a lateral pipe. Figure 7 shows a close-up of this lateral pipe – already broken, probably from pedestrian/equipment weight. All piping should have ample clearance between valve boxes. Not completely visible is a mainline directly under the lateral, or "stacked," which is a spec violation due to the difficulty in making future maintenance repairs. Pipes should be installed side by side with adequate clearance between.

Figure 8 shows signal wiring above the specified depth of 18-inches (mainline depth). Shallow wiring is vulnerable to landscape and utility work. Note that the metallic warning tape was installed by UW Irrigation, not the contractor, as a post-installation damage countermeasure.

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

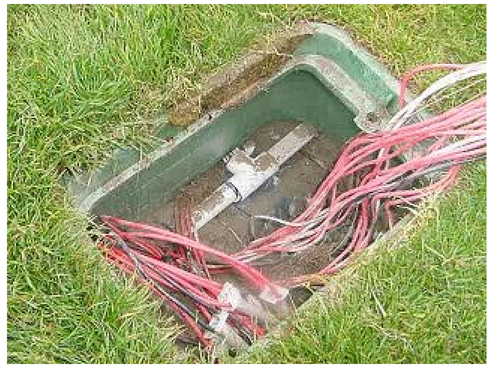

Figure 6

Figure 7

Figure 8

Future Irrigation Construction Management Issues

- Term Contracts for irrigation subcontractors instead of the quo “low bid” format; research legality, apply
- Contractor Performance Evaluations; research legality, apply
- Require that contractors have training credentials (e.g. Irrigation Association Certifications); research legality, apply
- Continuous Improvement of the UW FDI; also, research new issues: impact of the use of reclaimed water on irrigation products and designs; impact of district, state and federal water policy on irrigation products and designs

Concluding Remarks

The previous examples of irrigation design and installation quality control issues are merely the tip of the iceberg. It should be apparent that such shortcomings, collectively, can significantly reduce project quality, increase project costs, and increase future maintenance costs. Scrutiny and involvement by Irrigation Specialists during the entire Capital Projects planning and construction cycle can improve project quality, reduce project costs, and reduce future maintenance costs.

Footnotes

[1] Rain Master central control via radio and phone modem. Conservation and control features include integrated flow sensors, master valves and soil moisture sensors.

[2] Over $700 million worth of capital project development since 1996 ("The price of civic pride," Seattle Times, A12-13, 07/18/99). Most included landscape and irrigation. Note impact on existing systems (e.g. construction damage, existing and new system interfaces). A 1999 UW Irrigation Automatic Irrigation Growth Study showed the following increases since 1991: 122 percent in systems, 101 percent in valves, 94 percent in sprinklers, and over 6 miles of drip which was nonexistent in '91.

[3] Administration/Infrastructure, Central Control, Maintenance/Preventative Maintenance, Planning, Projects, Research & Development, Training & Information, and Water Conservation

[4] Microclimate variables: plant water requirements; hydro-zones; density, canopy and growth/maturity density; soil texture; soil structure; drainage; on-structure plantings; raised planters; effective seasonal sun path, exposure, reflective heat, and shading; wind exposure and average prevailing wind; rain exposure and rain shadows

[5] Calculation Tables

Program	Zone Run Times/min								Program tot min/ start time	Start times/ day	Total min/day	Days/ wk	Total min/wk
	Z6	Z7	Z8	Z9	Z10	Z11	Z16	Z17					
1	6	6	6	6	6	5			35	2	70	3	210
2							4	4	8	2	16	3	48
Total run time for the listed zones in minutes per week													**258**

Monthly Scheduling Adjustments (100% = full base schedule)						
Irrigation Months/%	April/May 50%	June 80%	July 100%	August 100%	Sept./Oct 70%	**Total Adjusted min/yr**
Adjusted min/wk	129	206.4	**258**	258	180.6	
Adjusted min/mo	774 (129)(6wk)	825.6 (206.4)(4wk)	1,032 (258)(4wk)	1,032 (258)(4wk)	1083.6 (180.6)(6wk)	**4747** (sum mo)

Yr	Tot Adj min/yr	Leakage (50 oz/min)(128 heads)	Total leakage oz/yr (adj min/yr)(leakage)	Tot leak gal/yr (tot oz/128oz)	Tot leakage CCF/yr (gal)(.001337CCF/gal)
'02	**4,747**	6,400	30,380,800	237,350	317.34
'01	4,747	6,400	30,380,800	237,350	317.34
00	2,064*	6,400	13,209,600	103,200	137.98
Water loss due to leakage from '00 through '02 if problem not corrected					**772.66 CCF**
Water loss in dollars @ peak rate of $2.75/CCF					**$ 2,124.82****

* Installed 09/00, new planting operated at 100% for two months prior to fall rain/winterization
** Not including time and materials costs