SMART

IRRIGATION NEW ZEALAND

Irrigation Development

BOOK 6

Contents

This book is part of a series providing a comprehensive training and reference resource for irrigation industry participants in New Zealand.

It covers the information required and the process to follow to develop an irrigation system.

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Irrigation development

The development process follows a logical series of questions and actions;

PRE-DEVELOPMENT

Firstly the case for irrigation must be established and an understanding of how the irrigation investment will:

A. Benefit the business? Analysing all of the options for how to best utilise the irrigation will mean the best return on capital will be achieved and will also influence the design of the system.

B. Affect family/succession circumstances and the farming/business model

Secondly after being happy with a decision to proceed the next questions to consider are:

C. Is the water affordable? Relative to business options

D. Do I have permission to take and use the water? What other consents are needed? How will irrigation and altering land-use alter my environmental footprint?

Finding the right people to talk to and gathering the right information, in a design brief, to provide to a designer will ensure the best irrigation system for the business is designed.

Irrigation can be a multi-generational investment so the current and future land tenure on which the irrigation infrastructure is built is an important consideration.

Figure 1. Decommissioned water race gate.

DEVELOPMENT

- Completing a design brief
- Specifying a design
- Designing the system
- Contracting installation
- Installation (build) to specifications
- Commissioning the new system
- Operation of the system.

POST DEVELOPMENT

- Maintain
- Evaluate.

This simplistic overview of what can be a complicated and technical process sets the outline for this book.

KEY CONCEPTS

- Irrigation affects social/family/business goals and plans. Ensure you understand the implications
- Undertake a cost benefit analysis of the business options – consider economic, environmental and social aspects
- Understand the level of investment needed
- Do not start an irrigation project until access to water (consent or shares) is assured

COSTS BENEFIT ANALYSIS
While irrigation will generally provide benefits that exceed cost, individual cases vary. Development proposals must be subjected to a cost benefit analysis to justify investment. It is a basic pre-requisite for funding and business that the benefits of any particular proposal exceed the cost over time.

Specifying irrigation systems

Specifying an irrigation system is a critical task. It involves determining all the requirements of the system and documenting them as a 'Design Brief'.

The *Design Brief Checklist* is a document published by Irrigation New Zealand. It sets out the process of information gathering and preparing a design brief specific to the property identified, ready to establish a design, construction and commissioning contract to ensure the irrigation system is built as required.

It is not anticipated that a farmer, or indeed a consultant or designer, can complete all the steps alone. To complete each stage, it is advisable to seek advice from properly qualified people. This will ensure the right information is gathered and appropriate decisions made in regard to the many design and construction options.

Every irrigation system is a unique solution to a unique set of circumstances; a custom design specific to the farm on which it is built.

It is advisable to review at an early stage all implications of irrigation development and investment. These discussions should involve bankers, accountants, irrigation service providers, peers and your family.

Information gathering

The first stage in specifying an irrigation system is gathering the core information that informs the design. This includes:

1. Site
2. Management
3. Regulatory requirements
4. Water source
5. Climate
6. Soils
7. Crop.

The required information will come from a range of sources and needs to be as site-specific as possible.

1. Site

KEY CONCEPTS

- Accurate information is vital
- Map the development at farm scale
- Consider the whole farm system and related infrastructure

LOCATION

Where is the irrigation system to be installed?

A full and correct site address, legal title description and owner information is important to ensure everyone involved knows exactly where the system is to be built and ensure correct consenting.

LAND AREA

Land area includes both the proposed irrigation system coverage and the total property area.

Some systems, including dairy effluent application areas, have a minimum area specified. This must be the effective application area, not including non-irrigable parts such as gullies or buffer zones.

PLANS/MAPS

A complete scale map of the area is the base for all system designs. It must identify all features that require consideration during the design process, including:

- Planned irrigated area
- Existing infrastructure (roads, fences, buildings etc)
- Power supplies
- Topography (slope and aspect)
- Soils and soil zones
- Crop boundaries where applicable
- Water source(s)
- Drainage patterns and streams
- Sensitive areas.

Ideally maps will be available in electronic format, but a good aerial photo or scale property plan does provide a suitable base.

Considerable care is needed if using GPS to make maps. It is advisable to get a professional service to create a highly accurate GPS surveyed map.

Figure 2. Control panel.

2. Management

The information needed here is the farm system information that a designer needs to know about. It includes:

- The system's intended purpose(s), expected service life, and acceptable downtime
- Animals that will be grazing on the area
- Labour availability and capability
- How the system will be operated and controlled
- The risk and investment levels the farmer has in mind.

Figure 3. Frost protection.

PURPOSE

Irrigation is the primary purpose however there may be other functions to include. Common extra functions are:

- Domestic water needs
- Stock water supply
- Frost protection
- Fertigation/Chemigation
- Sprayer filling
- Fire fighting.

Each of these extra functions can have specific performance requirements that influence design decisions. Designing for these at the outset is easier and cheaper than trying to retrofit them later.

REQUIRED SERVICE PERIOD (SYSTEM LIFE AND USAGE)

The expected lifetime, and the expected annual usage, has significant economic implications.

The system life span can be dependent on a number of factors. Consent duration, tenure of land, climate variability and capital versus operating costs should be taken into consideration. If the irrigation system has a very high probability that it will be used for the success of the crop grown versus using it as an insurance cover in areas of more reliable rainfall then the level of investment could alter. In the situation where the usage is more erratic a lower capital cost and higher operating costs may be more acceptable. For example, a manual move system (sprayline or long lateral) is less expensive to install than a pivot, but has significantly higher labour demand.

To accommodate future expansion or land use change, system design may select (initially) over-sized mainlines to allow future higher flow demands.

SYSTEM DOWN-TIME

System down-time refers to failure of the irrigation system rather than failure of water supply. Not being able to meet irrigation demand incurs a cost. If a crop has high value, additional 'fail-safe' options can be justified. Examples include back-up pumps, alternative power supplies and higher quality components or inventories of spare parts held on farm.

ANIMALS

Identify the type of animals (usually related to the purpose) that will be grazed and interact with the system lets the designer know how robust the componentry needs to be and what other factors such as fencing and stock water to include.

LABOUR

Identify the available labour and preferences for labour required to operate irrigation. Consider both the physical and intellectual capacity needed. This can tie in with and influence the level of automation and how the system will be controlled and operated

INVESTMENT AND RISK

Identifying levels of preferred system lifespan, investment and returns and indicating the capital budget available and the financing proposal gives the designer information on what systems and levels to consider. The level of investment and mix of capital versus operational expenses may influence the longevity and type of system designed. Identifying how critical the irrigation system and its reliability are to the business can influence the system type, system capacity, requirements of servicing and inventory of spare parts needed.

3. Regulatory requirements

Legal requirements are covered in more detail in Book 2 of this series. There are potentially many 'permissions' and consents required to develop an irrigation system. Regional and unitary authorities are responsible for the administration and provision of consents.

Irrigators need to find out exactly which permits and consents are needed before getting underway. Do not start an irrigation project until access to water is assured.

In every case, taking and using water is subject to Resource Management Act (RMA) provisions. These include both regional plan rules and resource consents.

Resource consent processes include assessment of effects for affected parties (other stakeholders) as well as effects on the environment. Early consultation with neighbours and other stakeholders can be beneficial.

Where water is supplied by an irrigation scheme, the consents to take and use water are held by the scheme. New irrigation sourcing water from the scheme requires scheme permission. This may include purchase of shares.

On-farm storage may require consent under the Building Act (2004) depending on stored volume and bank height. It may be subject to on-going engineering structural checks and reports.

Irrigating leasehold or rented land may require lessor permission, and in some cases agreement about cost sharing.

The authorities and the general public expect all new irrigation developments to operate at good practice from the outset to minimise any effects and maximise the efficient use of what is a public good.

4. Water source

KEY CONCEPTS

- Water supply reliability needs to be understood – it will influence what is feasible
- Water is expensive to move (energy cost)
- Knowledge of the water supply quality characteristics is essential

WATER SUPPLY

The water supply is the heart of any irrigation system, and can be the controlling factor in irrigation feasibility. The volume, timing and reliability of supply can have a bearing on what land use occurs with irrigation.

Supply determines the area of pasture or crop that can be effectively irrigated, and has a large influence on the profitability of irrigation. If water is not available at reasonable cost, irrigation will not be financially viable.

It is vital that an assessment of water supply availability, reliability, quantity and quality is made before progressing.

The most common sources of water are:

- Groundwater (shallow or deep aquifer)
- Flowing surface water (streams, rivers, drains)
- Surface water harvested into storage
- Irrigation scheme – from surface or stored source
- Municipal supply
- Sewage or industrial wastes.

FURTHER INFORMATION

Ground, surface and stored water are covered in more details at the end of this booklet in the *Extension resources: Water sources*.

The reliability and adequacy of supply within season and between seasons must be considered, regardless of the source of water.

Locating a water source may be an easy task if a stream or river is available or if proven groundwater exists. However, a guaranteed supply is not always available.

Groundwater can be a more dependable source of water than surface water takes. It is a form of natural storage that does not suffer from evaporation losses and large within-season fluctuations to the same extent as water taken from flowing sources. However many ground water sources are hydraulically connected to surface water bodies and **ground water** take consents can have conditions subject to **surface water** levels.

Generally, both surface and groundwater supplies in New Zealand fluctuate significantly during the irrigation season. Both are replenished by rainfall but the time spans to increased levels and flows differ.

When annual withdrawals from groundwater systems exceed replenishment, water levels fall. Lower water levels increase pumping costs, and can make abstractions difficult or impossible. Energy requirements for pumping strongly influence irrigation costs. The cost of lifting ground water to the surface is dependent on the depth it is being pumped from and can be significant.

Therefore detailed knowledge of water supply reliability is essential. Just because the water is easily available today does not mean it will be as freely available tomorrow.

Accessing any water supply has an initial cost of development, and on-going delivery costs of energy, maintenance of infrastructure and consents. Conserving water and energy is important in maintaining a sustainable irrigation system.

WATER QUALITY

New Zealand's natural water is generally of excellent quality and suitable for most irrigation without treatment. Micro-irrigation systems justify increased caution and care when selecting a water supply.

Cases where water quality can and does require consideration include:

- Sediment loads and foreign matter
- Chemical contaminants
- Biological contamination.

Sediment and foreign matter

The main problem with sediment is pipe and sprinkler blockage. This can be managed by appropriate separation or filtration. Sharp sands also cause wear of components, especially where velocities are higher such as passing through valves and nozzles.

Clay contamination is a particular issue for micro-irrigation systems with low flows, low pressures and very small orifices.

Foreign matter includes any other physical contaminants from a variety of sources. Water sources can contribute weed, algae and small animals. Where effluent is spread from a holding pond the effluent itself, windblown sticks, sawdust, etc get through pumps and end up in sprinklers. Larger particles are easily removed through filtration but all filtration mechanisms increase energy use and costs.

Chemical contaminants

In some regions, iron and other chemicals can cause problems. This is usually a problem for micro-irrigation systems, but horticultural crops can be damaged by staining from overhead application.

Treatment is possible, but can be expensive when large volumes are involved.

Biological contamination

Micro-irrigation is most at risk of biological contamination. Algae growing in lateral lines and emitters reduce application rates and can cause system failure.

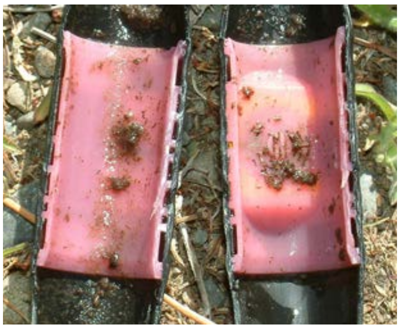

Figure 4. Dripper affected by algae growing in the lines.

Treatment methods to combat these issues include periodic acid injection or chlorination, and should be considered in the system design (inclusion of injection points).

Weed or nuisance algae growth such as Didymo from affected rivers can also be problematic for all spray irrigation types, frequently resulting in blocked irrigation water intakes and nozzles.

Solutions to nuisance weed and algae growth, such as self cleaning screens and filters, should be considered in the design stage where known issues exist.

Physical abstraction rate

The physical abstraction rate is governed by the size of the water supply and pump.

A well will have a maximum ability to supply water because of aquifer properties (water depth, yield), well diameter and screening.

Pump size dictates the maximum amount of water that can flow through the irrigation system at any given pressure.

Legal abstraction rate

The legal abstraction rate is determined by regional rules or consent conditions.

The maximum legal abstraction rate may be capped to protect a surface water source or to limit draw-down effects on neighbouring wells within an aquifer system.

Irrigators need to find out exactly which permits and consents are needed before getting underway. Do not start an irrigation project until access to water is assured.

5. Crops

KEY CONCEPTS

- Water use varies with crop type and growth stage
- Crop rooting depth determines how much of the soil's profile available water can be used
- The distribution uniformity (evenness of application) required is influenced by crop type
- Match the irrigation system design to the crop

The primary function of irrigation is to maintain a steady supply of water for crops to use. Crop water use varies influenced by prevailing weather conditions, available water in the soil, crop species and growth stage.

The needs of all proposed crops should be ascertained before an irrigation system is designed. This will ensure the cumulative simultaneous demand and overall seasonal volume demand can be met. Alternately if the volume and/or reliability of supply is constrained this may influence the land use that occurs.

Figure 5. Wheat crop.

CROP TYPE

Pasture for livestock production has a relatively constant demand for water, varying in response to daily and seasonal weather conditions.

Arable, vegetable, vine and tree crops have different water needs as they pass through vegetative growth, grain and fruit development and maturing stages. Their exact requirements depend on the crop and the end product.

Specific crop needs may influence choice of irrigation type. The suitability and practicalities of using the irrigator over the crop should be considered. If specialist arable or tree crops are being grown, factors such as irrigator access, droplet size, precise placement of water and other attributes should be matched with crop sensitivities and need. Small seedlings and plants such as salad crops are sensitive to droplet size and impact. Soil splash and leaf wetness can promote disease or affect crop quality, so irrigation intensity and return interval (set interval versus as and when) must be considered.

MINIMUM UNIFORMITY (DU_{LQ})

This is a measure of how evenly the irrigation needs to apply water, depending on the crop type. The range of uniformity depends largely on depth and width of a crop's root structure. Uniformity is the evenness with which the crop receives irrigation. Higher value crops with smaller plants and shallower roots on coarser soils require higher uniformity.

CROP ROOT DEPTH

A plant's rooting characteristics determine how much of the soil moisture can be accessed by the plant. A deep-rooted crop has access to a greater amount of soil moisture than a shallow-rooted crop, usually allowing it to go longer between irrigation events. This can have a bearing on the system return period designed.

CROP FACTOR

Different crops, stages of crop growth and different ground cover fractions have different water requirements. The crop factor adjusts actual crop needs from the potential needs using an indicator crop (usually pasture) to determine potential evapo-transpiration – the main indicator of water requirement. The crop factor coefficient to use influences the system peak capacity.

MANAGEMENT ALLOWABLE DEPLETION

The management allowable depletion is a management factor that describes how much soil-stored water can be used before irrigation is warranted. Typically about half the available water can be used without a crop experiencing stress. However this does vary, and sometimes stress is desirable to manipulate crop growth or development.

6. Climate

KEY CONCEPTS

- Rainfall and ET combined determine likely water shortage and irrigation demand
- ET is the key determinant of peak system capacity
- Rainfall is variable and site specific data is required
- Overall climate influences land use choice
- Wind is important for uniformity, orientation, set-up

Figure 6. Rain gauge.

EVAPO-TRANSPIRATION

Evapo-transpiration determines likely crop water needs. The demand in the peak month is a key factor in determining the required system capacity. Together with rainfall it is a key design determinant of an irrigation system's required capacity and the likely seasonal and instantaneous volume required for the irrigated area.

RAINFALL

Rainfall is the most variable factor and significant variations can occur over relatively short distances. Knowing the patterns and long term average over a season helps determine the seasonal volume. Accurate rainfall data specific to the property is ideal.

TEMPERATURE

Under normal growing conditions, temperature is the main environmental factor controlling development in all crops. Development relates to the formation of new plant parts (e.g leaves, flowers, roots) and is physiologically different from growth (i.e. dry matter accumulation). Growth is driven mainly by net photosynthesis, which amongst other things (such as light intensity and resource availability) is also dependent on temperature.

Growing degree days, a measure of days during which crops will grow, influence the length of time a crop will take to reach maturity. This can have an influence on the type or rotation of crops grown. Likelihood and timing of frosts is another consideration when developing irrigation and land use options.

Soil temperature trends influence the need for irrigation especially at the start and end of the growing season. At soil temperatures below 9–10˚C plant growth slows or stops and soil moisture deficit is not the primary limit to plant growth. Applying irrigation will not accelerate growth and is likely to slow growth by slowing the warming of the soil.

WIND

The main problem of wind is its effect on distribution pattern. A strong wind can blow sprayed irrigation water off target. Knowledge of wind patterns can help select a system type or make design or system adjustments to account for its effects.

Figure 7. Knowing the soil profile is a first step in determining irrigation system specifications.

7. Soils

KEY CONCEPTS

- Obtain detailed farm scale soil maps
- Know the key soil characteristics
  — Soil infiltration rates
  — Water holding capacities
- Soils are a key determinant of system design

Soil information is a key determinant of irrigation system design. Book 4 in this series 'Irrigation Essentials', provides a comprehensive resource to understand the implications of different soil properties.

New Zealand has very diverse and changeable soil types. Frequently, changes from deep to shallow and coarse to fine textures are found over very short distances. For successful irrigation development, a property's soil characteristics must be mapped at farm scale.

The main soil properties of interest are:

- Soil infiltration rate
- Soil depth
- Water holding capacity
- Drainage characteristics.

Soil texture and structure affect infiltration and water holding capacity.

Soil information helps determine:

- The type and flexibility of irrigation system selected and how it must be managed
- Maximum application intensity – soils with low infiltration rates will require a system with matching application intensity
- Maximum irrigation depth– soils with low water holding rule out irrigators that cannot apply small depths
- The range of crops able to be grown. Different soil types are more suited than others to particular crops.

Development process

KEY CONCEPTS

- Consistent clear information is important
- Design inputs must be comprehensive to cover all parameters
- Design outputs must show the design will achieve required performance
- Formal contracts are essential for all development and upgrades
- Contracts must be comprehensive
- For more information and templates to use contact IrrigationNZ at www.irrigationnz.co.nz

Design

DESIGN BRIEF

The design brief forms the basic information that enables an irrigation design to be completed. It includes a list of performance factors the design must meet if the system is to achieve expectations.

They include:

- Required service period – how long the system should last
- Allowable system down time – days out of action when needed
- Minimum application uniformity – evenness of irrigation
- Maximum soil application intensity – thunderstorm or shower
- Maximum daily application depth – rainfall equivalent per day
- Maximum return period – time between successive irrigations at one place
- Maximum water abstraction rate – the rate at which water can be taken from water source
- Volume of water required per season – amount of irrigation needed in addition to rain
- Storage volume required – if a buffer such as a pond is needed.

The design inputs tell the irrigation designer what the system must achieve.

DESIGN OUTPUTS

This is information that comes out of the design process and describes a number of measurable factors about the proposed system's performance. These factors are part of system commissioning and on-going performance monitoring.

The design output information also allows a fair and convenient way to compare different design options.

Figure 8. Trenching.

Design outputs include:

- Economic variables
  - — Capital and operating costs
  - — Power, labour and maintenance costs
- System duty points
  - — System flow rate
  - — System pressure at key points
  - — Motor and pump efficiencies
  - — Maximum and minimum pipeline velocities
- Equipment and materials selected
  - — Storage
  - — Motors and pumps
  - — Filters and water meters
  - — Pipes and valves
  - — Sprinklers and emitters
  - — Control system.

Contractors

DECIDING WHO TO USE

There are a range of consultants, irrigation supply companies and installation contractors covering multiple or separate facets of the development process. The basic process is illustrated below with relevant documentation placements and independent input suggestions included.

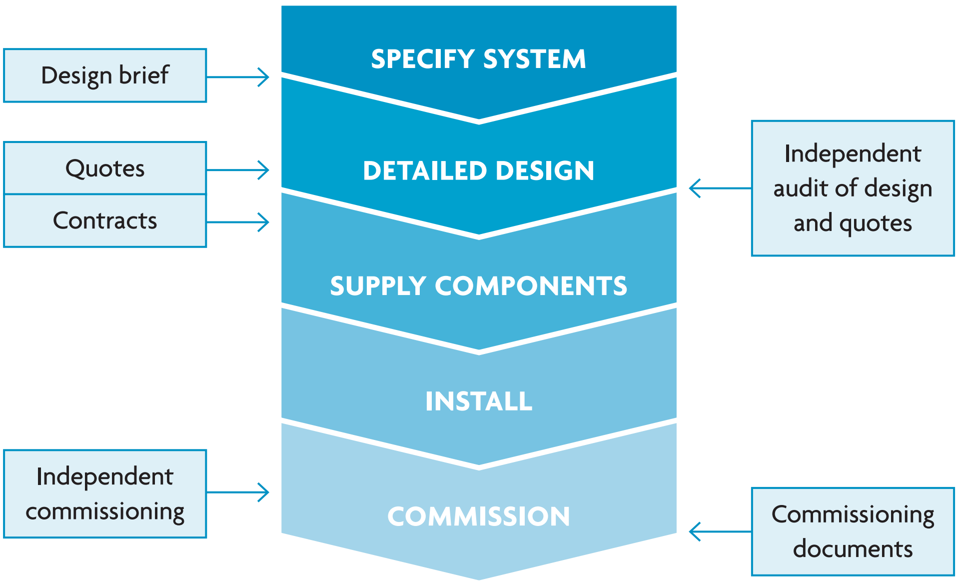

Figure 9. Basic process

The decision on who to advise, design, install and commission will depend on a range of factors. Background research and discussions with the contractors allow you to gauge if they fit with you and what you want to achieve. The relationship built, personnel, associated services provided (after sales service, ongoing maintenance, data management) and the levels of service are all as important as cost in influencing which company or contractor is awarded the work. A strong relationship enables discussion on price and delivery with a preferred contractor.

Irrigation companies that supply equipment typically have design and install capabilities. They can help you through the whole process. Independent consultants and advisors are able to help with the two bookends of specifying and commissioning and provide design audits. Independent advice during the design and commissioning phase can ensure the system you are paying for meets specifications required and the industry standards. It ensures the system will be cost effective from both capital and operating cost perspective.

QUOTES AND TENDERS

Quotes and tenders are similar processes.

A quote is a list of a vendor's price for supply of goods and services. Quotes set expectations and clarify the costings and delivery of a system.

Quotes allow for:

- negotiation of the supply of goods and services leading to an agreement with a company. The negotiation is an important part of building working relationships between farmer and contractor. This relationship is a key component when developing, changing, or adapting irrigation
- different companies to quote different products of varying price, brand and specifications to achieve the same desired key performance indicators (KPI's) as set out in your design brief
- giving the customer a firm idea of what different options will deliver and at what cost
- comparison across different companies, the systems they design and the components they use.

Quotes may be provided once a final design has been decided on; or it could be a final stage to decide between similar designs. Once a quote is accepted this can be drawn into a legal contract.

If considering multiple contractors obtaining quotes creates competitive tension and is an opportunity for the farmer to "shop around" enabling value for money. Value for money is the operative term as the least cost quote may not necessarily deliver the best value for money in the long term.

Tendering is a more formal process. It is a final price against defined specifications. Tenders are compared and one approved accordingly. Tender documents lay down the terms and conditions of the offer and they are normally requested to be submitted by a set date and time.

An open tender is where any contractor can put forward a proposal for the work requested. Closed tender, only certain contractors (already decided) put forward their offers.

ACCREDITATION

Irrigation New Zealand have an accreditation program for companies providing design services for both freshwater and effluent system design. Using a company with accreditation will ensure the completeness of the design and industry codes of practice and standards are met.

HOW TO PREPARE TO ASK FOR QUOTES?

For the farmer/grower

Knowing what you want is the key when asking for an initial quote. The Irrigation New Zealand guide to writing a design brief is the minimum amount of information that should be provided for a designer.

Clear goals, clear direction and defined specifications enable different contractors to quote for the same thing. This consistency is important to be able to compare between quotes. The importance of communicating the expectations on both the level of detail required and the key performance parameters to be met, is a vital role for the farmer.

For the company

Providing the client has given clear specifications, writing a successful quote can be achieved by ensuring the work that you plan to carry out, is written in a detailed, organised and realistic way.

- Breaking down the project in parts can help clearly get the plan across. Describe how the project will be managed, including estimated timelines.
- Detail the components, specifications and price for every part, ensuring that you show how you arrived at each price. (Laying it out in tables helps provide a clearer explanation.)
- If needed name any subcontractors that will be used, stating the name of each and what they will be responsible for.
- Outline all payment conditions and methods of payment in as much detail as possible
- Outline any guarantees that your company can offer, Health and Safety procedures and if applicable, insurances.
- Explain your company's capabilities and track record to get the job done.

A full description of what to include in a quote is included in the extension resources section.

The Health and Safety of contractors on your land is your responsibility so having this aspect covered is important.

COMPARING QUOTES

Being specific when initially requesting a design and associated quote will make it easier to compare "apples with apples" as the different quotes should cover the same specifications and performance indicators. Using independent advice and expertise at this stage provides a chance to peer review each design to check its suitability.

When assessing quotes make sure:

- Baseline assumptions are stated for instance exchange rates and the design brief key performance indicators
- All specifications and requirements are factored in or accounted for
- Key components meet specifications
- The quality of the materials are identified
- Costs are clearly defined against components and services
- Both capital and operating costs are accounted for (routine maintenance, energy, labour costs of operation, machinery needed to operate)
- Any associated costs of electrical, earthworks, travel, insurance, accommodation etc, are accounted for
- Life span of components and expected replacement schedules are included
- Is there a contingency for the unexpected?

CONTRACTS

Contracts allows all parties involved to have clear definitions of what is expected in terms of timeframes, materials, products and services, costs and levels of service provided.

Contracts are a legally binding document between two or more parties and are considered valid when:

1. There is an intention to create binding legal relations
2. An offer and acceptance has been made
3. Consideration to benefit the other party (i.e. money or the goods/service)
4. Legal capacity of the parties to make the agreement
5. General consent of the agreement
6. Legality of the agreement.

Contracting involves a number of specialist tasks and legal conventions. Large projects warrant professional support in setting and managing contracts. Smaller projects do not have the same risks, but still justify care in contracting. If nothing else, the parties involved need to have a record of what they agreed to do.

Irrigation New Zealand has developed resources specific to contracting irrigation projects. In general, some items to check are:

- How is the contract structured? Is it clear and concise?
- What contract standards will apply? i.e. NZS 3910 or something else?
- What payment structure is agreed? i.e. Lump sum or measure and value?
- Which costs are fully covered within the contract price?
- Is commissioning included?
- Which costs are not covered, tagged or may vary? e.g. Consenting, power connection, trenching or anything else?
- What provision is made for retentions? Do they cover practical and final completion, and maintenance period?
- What insurance cover and/or bonds are in place? Who is responsible, during transit, construction, during commissioning? Will the level fully protect both parties?
- Who is the contractor?
- Who is the Principal? Is it you?

The purpose of a contract is to ensure that all parties involved have a clear outline of what is expected of them to achieve a stated outcome. They ensure accountability and provide protection for all parties.

Should there be any disputes, contracts clauses outline process to be followed so they can be cleared up in a timely manner. This provides security in the fact that everything was decided, is written down and agreed to in a legally binding agreement. When drawing up a contract with the contractor it can give a good indication on how the relationship is going to continue throughout the process.

SUITABLE CONTRACTS

There are two main contract templates suitable for irrigation development each designed for various work thresholds. These are the Irrigation New Zealand Standard Installation Contract and NZS3910:2013.

Irrigation New Zealand Standard Installation Contract

The Irrigation New Zealand Standard Installation Contract is designed to give both the contractor and purchaser clarity on what is stipulated regarding what they are buying/supplying, and that all parties have the same expectations. Compared to the NZS3910:2013, the Irrigation New Zealand Standard Installation Contract is a simplified agreement that is better suited to on-farm works. This contract has no independent, so the farmer deals with the contractor directly. This contract is available on the Irrigation New Zealand website and is written with explanations in layman's language.

NZS 3910:2013

The NZS 3910:2013 is better suited towards off-farm irrigation Infrastructure or larger farm developments with values in excess of a million dollars. Being the most widely used contract in New Zealand, the NZS3910:2013 is designed to have an engineer that manages the contract on the property owners' behalf. The engineer is completely independent of the contractor and is generally under a separate contract. This can be helpful should disputes occur and a quick solution be needed to maintain a successful relationship between farmer and contractor.

Legislation

There are various laws that are relevant for irrigation developments. Clear understanding of them reduces any errors or omissions when drawing up contracts. Outlined below is legislation that should be taken into consideration when going through the process of forming a contract. Having a sound knowledge of these Acts, can provide extra security should it be needed at any point during the construction process. They apply to all parties over the term of the contract, and present pathways which can be taken should there be any disputes or disagreements.

FURTHER INFORMATION

An in-depth explanation of some of these Acts can be found in Irrigation New Zealand's *Irrigation Legislation, Regulation and Sustainability Book* (Book 3 in this series).

HEALTH AND SAFETY IN EMPLOYMENT ACT 1992

This is a critical component all contracts; the objective of the Health and Safety in Employment Act (1992) is to promote the prevention of harm to all people at work, and others in the vicinity of places of work. Every development that is done must comply with the Health and Safety Act. Both the developer (responsible for the contractors and the public/others coming onto the farm) and the contractor (their employees producing the goods/services,) must provide a safe working environment, and ensure all goods and services are produced, and can be used, in a safe manner; to the standards set out and imposes duties on employers, the self-employed, employees, principals and others who are in a position to manage or control hazards.

Having clear boundaries set out in the contract as to what is expected of all those on site in terms of Health and Safety regulations, covers the parties should something happen. For example a meeting may be put in place to identify any potential hazards present before work begins.

RESOURCE MANAGEMENT ACT (RMA)

The RMA governs how the environment is managed. It focuses on how everyday activities effect the surrounding environment including freshwater, soil, air and the coastline. The RMA's focus is on managing the effects that activities have on the environment.

While the RMA provides a guide to what's important in our environment, it generally leaves the decisions about how to manage the environment to the regional and local community. It encourages communities and individuals to have their say on what they regard as the best approach to managing their environment.

The RMA is administered through resource consents via unitary authorities, district and city councils. They are needed for various components of development including if the development includes disturb waterways, dam, divert, take, use water etc. Gaining consents is the developer's responsibility and must be granted before any work begins. *General requirements for resource consent applications can be found in Irrigation New Zealand's Irrigation Legislation, Regulation and Sustainability Book (Book 3 in this series).*

BUILDING ACT 2004

The Building Act (2004) is the legislation that governs the building industry in New Zealand. The act aims to improve control of, and encourage better practices in, building design and construction. This means:

- More clarity on the standards buildings are expected to meet
- More guidance on how these standards can be met
- More certainty that capable people are undertaking building design, construction and inspection
- More scrutiny in the building consent and inspection process
- Better protection for homeowners through the introduction of mandatory warranties.

Importantly for irrigators, dam construction and safety are covered under the Building Act.

The Building Act is implemented by unitary authorities, district and city councils. As per the RMA, it is given effect to by provisions in local plans (district plans) and the resource consent process.

CONSTRUCTION CONTRACT ACT 2002

The purpose of this act is to define payments schedules. A contract should clearly outline the number of payments and the amount and timing of each payment. Usually payments will be expected to be settled after each phase of the job has been completed and commissioned. Most things that may be done to a building including alterations and/or maintenance are covered by the Construction Contract Act.

Including a clause regarding the payment structure it is helpful to understand what you (either as the customer or contractor) are entitled to. For example, if a disagreement occurs on how much needs to be paid for a certain part of the work completed, the customer can give the contractor a schedule of how much they think they should pay, clearly showing how the amount was calculated. If an agreement cannot be reached, under the Act the independent adjudication process can be used to provide a solution.

SALE OF GOODS ACT 1908

This act provides protection for any goods purchased. It ensures all goods sold are fit for purpose and of high quality.

FAIR TRADING ACT

The fair trading act ensures that you are not being misled in any way or being treated unfairly. This means all costs and programs of work are clearly outlined. This act will cover the customer for example if the contractor does not make the price explicitly GST inclusive or exclusive. The main difference between this act and the Consumer Guarantees Act is that the goods and services claims are covered under fair trading before they are purchased, whereas the Consumer Guarantees Act covers them after purchase.

Construction

A construction checklist helps ensure the system is built as designed and clarifies responsibilities, construction details and costs.

CONSTRUCTION SPECIFICATIONS

The construction specifications deal with the specific issues needed to successfully complete the works required. Check that the following items are known and satisfactory:

- Project Plan
  - — Is it realistic?
  - — Are the contractor and sub-contractors sufficiently resourced?
  - — What methods and standards will be used?
- Commencement and completion dates and any consequences of failure to meet them
- Contract Duration. Has the 'Critical Path' been identified to ensure efficient progress?
- Is the scope of work clearly defined?
- Is the schedule of quantities clearly defined?
- Construction Methods and Standards
  - — Storage, intake and wells
  - — Motors
  - — Pumps
  - — Filters
  - — Pipes
  - — Automatic and manual valves
  - — Emitters and lateral
  - — Control system. Are their methods and standards valid?
- Who will be responsible for practical commissioning and completion and what standards apply?

PEOPLE AND CAPABILITIES

Make sure the contractor has people allocated to your project who have the required skills and experience. Ask for references and undertake background checks of previous projects they have been involved with.

HEALTH AND SAFETY

While a contractor is responsible for the health and safety of their staff, the land owner/purchaser also has responsibilities. Make sure that any on-site hazards are clearly communicated to the contractor and retain written evidence of this.

Among the hazards that may be present are:

- Working at height
- Working in trenches
- Working with electricity
- Working with pressure
- Working in wet, muddy slippery conditions
- Stock
- Other on-farm machinery and operations.

System commissioning

KEY CONCEPTS

- Commissioning is an important process. It is the quality control ensuring the system is installed and operating correctly
- Commissioning component needs to be written into contract

The commissioning process will determine whether or not all components of the system are installed and operating properly, in accordance with the system's specification over the range of on-site conditions expected.

Commissioning is a technical task completed by trained people. It includes:

- System testing
- Procedures for correcting poor performance
- Documentation that needs to be provided
- Producing as-built plans

FURTHER INFORMATION

Information in more detail is provided in the Extension resources: *Commissioning Irrigation systems.*

Operation

Development is only part of the story. To achieve economic, sustainable and optimal irrigation, each of the key components (specify, design, install, maintain, operate and evaluate) must be correctly completed and revisited. That will ensure on-going sustainability and continuity over the investment time frame.

Extension resources

Figure 10. Deeper groundwater must be accessed by bores.

Groundwater

Find out what depth groundwater is likely to be found and in what volumes.

You need to ensure that you can still obtain an adequate and reliable supply of water during droughts. To achieve this:

- Talk to neighbours or locals familiar with the groundwater in the locality
- Talk to well drillers
- Contact the local regional council for details about groundwater in the district
- Talk to irrigation consultants who have been involved in groundwater studies in the district
- Find out as much as possible about how water levels fluctuate, both within seasons and between seasons.

LOCATION OF WELLS

The number of wells, approximate location for wells and well diameters need to be estimated before obtaining resource consents. You also need to assess an approximate water supply cost to determine if irrigation is likely to be financially viable.

The exact location of wells needs to be decided as part of the design process.

Factors that affect well locations include:

- Likely location of aquifers
- Flow rate required
- Location of power supply
- The design of the irrigation system
- The effect on the hydraulics of the irrigation system
- Proximity of nearby wells
- The effect of abstraction on nearby wells
- The effect of pumping on streams–connectivity
- Distance from the coast (in case of saltwater intrusion).

If groundwater is shallow, galleries or shallow wells may be dug with excavators. For deeper groundwater, properly constructed wells are advised. Generally the deeper the groundwater, the more reliable the supply.

Shallow wells are often hydraulically-linked to nearby rivers or streams that can become very low in late spring/summer/autumn and can dry up in extreme cases.

In areas where more than one well may be required, allow for possible locations for additional wells in a way that allows them to be spaced as widely as possible, as far away from neighbours as workable.

On flat ground, ideally wells should be placed near to the centre of the land to be irrigated. This results in the lowest pipeline cost because shorter runs and smaller pipe diameters can be used.

If the property is sloping, the well should be placed towards the high end of the property. However, depending on the degree of slope and length of run, the highest point is not usually the optimum location.

As a guide, on typical farms with a fall of 1 in 100 to 1 in 200, the well could be located about one third of the distance from the top of the farm, thus pumping one third uphill and two thirds downhill.

Sometimes, more than one well is required to feed into a single system. Proper location of each well is vital to the cost and the long-term operation of the system. Multiple water supply systems can be hydraulically complex, and experts should be consulted.

Other factors to consider are the risks of contamination by chemicals, nitrates, etc.

The best advice is to have a number of options designed and priced for a range of well positions before the wells are drilled. Remember, you pay for installation costs once but you pay for design inefficiencies for the life of the system. There is no cost to the user to transport electricity through wires but the cost to push water through pipes is on-going.

Figure 11. Power must be available.

GROUNDWATER COSTS

Obtaining irrigation from groundwater generally includes the following costs:

Initial installation

- Well drilling
- Well screen
- Well development
- Pump
- Pump column
- Pump cables
- Electrical switch gear/equipment
- Power lines
- Miscellaneous hydraulic valves/headworks
- Pump shed
- Consent applications

Operation and maintenance

- Electricity capacity and fixed charges
- Electricity energy charges
- Diesel cost (if appropriate)
- Operational labour costs
- Repairs and maintenance to wells and pumps

Financial

- Costs of capital/borrowings vs debt servicing (and repayment)
- Depreciation.

Surface water

It is essential to determine if a reliable water supply is available and how it can be supplied to your farm. An indication of how much it is likely to cost must also be obtained so that it can be factored into the initial economic evaluations.

Lakes, streams, rivers, drains and artificial ponds are the most common sources of surface water for private takes.

LOCATION

If water is to be gravity-fed for surface irrigation, it should almost always be supplied to the highest point of the irrigated area.

If water is to be pumped for surface irrigation, it should also be located at the highest point in the field, although in some systems it is cheaper to pump small quantities of water to localised high spots than it is to pump all of the water to the highest point. Electricity line supply will often dictate whether that is possible.

INTAKES

Figure 12. Surface intake using rotating screen to clear debris.

There are a number of options for intake structures to take water from a stream, river, lake or other surface water resource. The options are:

- Dam
- Diversion weir
- Whole channel diversion
- Partial channel diversion
- Open gallery
- Buried gallery.

Small systems may use a direct suction take with a simple screen to minimise contaminant entry.

CONVEYANCE METHODS

The main methods of conveying water from a surface water source to an irrigation system are canals, flumes and pipelines.

Canals

Canals, also known as ditches or laterals, are open channels used to carry irrigation water.

Canals can cause more trouble in operating an irrigation system than any other conveyance method if not designed and maintained correctly.

Weeds and other vegetation remove water through evapo-transpiration. Rabbits and other pests may damage canal walls. Also, bridges or culverts are needed to cross roads and other waterways.

Most canals are unlined. Small canals can be built and maintained with farm equipment and may be permanent or temporary. Larger canals will require large earthmoving machinery.

High velocities can erode canal walls so take care where grades are steep. Drop structures may be needed to dissipate excess energy.

In some soils, particularly porous sands or gravel, seepage can be a problem. This can be a significant problem on long canals.

Canal lining can reduce or eliminate seepage and minimise bank erosion. It also gives some protection from rabbit damage and reduces water logging of adjacent land. Artificial lining provides a more dependable water delivery method and helps to control weeds.

Flumes are artificial channels supported by substructures. They are often used where canals are not practical or along steep or rocky hillsides, and tend to be used for carrying smaller quantities of water than unlined canals.

Low pressure pipelines
These are similar to flumes except that the pipelines are usually designed to run full under low pressure.

They are often used on surface water systems where the water does not have to be delivered under pressure. They have the advantage of being lower cost than high pressure pipelines and are 100% efficient.

Provided that they are well-maintained and are not leaking, there will be no losses.

Because they rely entirely on the forces of gravity to provide the pressure to move the water, diameters tend to be larger than for high pressure systems. If they are too small, the required flow of water may not be able to pass through them.

High pressure pipelines
High pressure pipelines are normally used where water is to be delivered to sprinkler irrigation systems rather than to surface irrigation systems.

Nearly all pressurised irrigation pipelines are permanent and buried. Construction materials include PVC, polyethylene, steel, ductile iron, Hobas and concrete. Pressurised pipelines provide the greatest advantage where sufficient down slope can be obtained to overcome pipe friction and build up enough pressure in the pipeline to operate sprinkler irrigation systems.

SURFACE WATER COSTS
It is difficult to provide budget figures for the cost of major surface water supply systems as the factors determining construction cost vary so much.

The only way to arrive at a sensible budget estimate is to carry out a pre-feasibility design and prepare cost estimates for it.

Scheme water

Much of the irrigation water in New Zealand is supplied by way of community based irrigation schemes.

Up to 1988, these schemes were primarily developed by central government. In 1988, government divested itself of irrigation scheme assets and ceased any involvement.

From that date, irrigation scheme development has been undertaken as private ventures. This means that all irrigation schemes must be economically viable to proceed.

Further irrigation expansion is possible on some existing irrigation schemes.

The allocation of water from each irrigation scheme varies greatly as does the basis and rate of charging. Current scheme water charges within New Zealand vary widely.

The low scheme water charges are usually based on covering operation and maintenance charges only and do not require a return on the original capital invested. The water charges on the newer private schemes are usually a combination of debt servicing and charges for on-going operation and maintenance.

Central and regional governments are again taking active interest in irrigation development. While support is increasing, full cost coverage is not likely. A form of public–private ownership may evolve, particularly where general community benefit is demonstrated.

Figure 13. Scheme intake fish screen.

OPEN RACE SYSTEMS

Most community irrigation schemes in New Zealand have traditionally been constructed as unlined canals.

This is because of substantially lower initial capital cost. Earth canals are relatively cheap to construct and maintain in areas that suit open channels. However, they do take up land area and normally have race losses of ~10%.

PIPED SYSTEMS

Piped systems offer considerable technical advantages over open race systems. Some of these advantages are:

- Water may be delivered under pressure to the farm
- There are less farm entry problems
- There are no evaporation or seepage losses
- Water quality is maintained
- Operation and maintenance costs are minimal
- Water can be obtained on demand, rather than on a roster
- Lower overall scheme capacities can be used
- Control of water to farms is relatively simple
- Pumping for spray irrigation systems may be eliminated or reduced considerably
- Pipes can be buried on road verges
- Hydroelectric power may be generated from pressure generated in the pipes.

The main disadvantage of pipe systems is that they are substantially more expensive in terms of up-front capital costs.

CONVERSION OF IRRIGATION SCHEMES

Increasingly, water use efficiency is being regarded as a key factor (particularly from an environmental/conservation point of view).

Land use changes are seeing conversion from surface to spray irrigation. Conversion can offer considerable benefits to existing scheme users and to new users.

Conversion of open race to piped irrigation supply systems is also finding favour. Existing users can receive pressurised water to the gate, significantly reducing energy costs.

The increased efficiency can improve supply reliability and provide the excess water for others, who may cover much of the cost of distribution system conversion.

Commissioning irrigation systems

Commissioning is a technical task completed by trained people. It includes:

- System testing
- Procedures for correcting poor performance
- Documentation that needs to be provided
- Producing as-built plans.

SYSTEM TESTING

The system must be tested by a qualified person and the results of the test supplied to the installer, designer and purchaser.

The system testing must be conducted at a suitable time so that the installer, designer, and purchaser can all be present.

System testing should include all new components, as well as all pre-existing components that are being incorporated into a system upgrade. This is particularly important for pumping stations.

Test the following during installation and/or prior to handover of the system:

- Pressure-test the pipelines at 1.5 times the normal operating pressure, if possible. If this pressure is not achievable with the installed pumping equipment, then pressure-test at the maximum achievable pressure
- Check that pump performance meets the specification
- Ensure that all irrigators receive the required pressure and flow rate
- Test all controls, cut-offs, and alarms
- Calibrate all flow meters
- Test water application depth, intensity, and uniformity under each irrigator
- Test all check valves and backflow preventers, including those on the intake.

The New Zealand Piped Irrigation System Performance Assessment Code of Practice (2015) has been developed to guide the testing process. There are also several existing standards that are specific to performance testing of irrigation components ('Standards Relevant to Testing and Commissioning').

Many pipe suppliers' technical documentation and pipe installation standards contain sections relating to pipe pressure testing ('Standards Relevant to Pipe Installations').

If any variations from the original design are identified during the system testing, these must be documented and recorded on the as-built plan and in the commissioning report.

Unless otherwise outlined in the contract, acceptable deviations from the system specification include:

- Flow rates must not be more than ± 5% of the design value
- Pressures must not be more than ± 10% of the design value
- Current (amps) must not be more than ± 5% of the design value
- Application uniformity must not be more than 5% under that specified.

FURTHER INFORMATION

A detailed description and guidelines for commissioning irrigation systems are included in Irrigation New Zealand's *Guide for Commissioning Piped Irrigation Systems.*

CORRECTING POOR PERFORMANCE

If system testing reveals that actual system performance does not meet the system specification, the fault must be:

- Corrected and the system retested
- Reported to the purchaser.

Any consequences of operating a system that deviates significantly from the system specification must be fully explained to the purchaser. The purchaser may decide whether or not to accept the system as installed.

If the purchaser decides that the system must meet the system specification, the designer or installer (whoever is responsible) must arrange for the necessary changes to the system to occur. This must be done in accordance with the original contract.

DOCUMENTATION

Figure 14. Checking critical points as part of commissioning.

Proper documentation is an essential part of the commissioning process.
The documentation should show that the system was checked, and that it was installed and working properly when it was handed over. It should describe the installation and testing procedures followed and the results obtained.

When an irrigation system is handed over to the purchaser, it should be accompanied by:

- A commissioning report
- As-built plans
- Operation and maintenance manuals
- Any other relevant supporting information.

AS-BUILT PLANS

As-built plans show where all componentry can be found, how the pipework system is laid out, control points and so on. It is the basis for all future management, maintenance and any system change proposals.

A final clear and concise readable plan, drawn to scale, with all key items located on the plan must be provided. Ensure that the plan provides accurate locations (accurate within ± 5 metres), dimensions and sizes of all key components in the system. This is particularly important for items buried underground.

Also provide a detailed plan of the pumping station and headworks, including below ground components.

Provide the as-built plans within one month of commissioning or within one month of making changes to the system.

Note: As-built plans may not be the same as initial design. That's the point of them.

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