

# North Dakota Stockwater Design & Workbook Tool User Guide



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**USDA NATURAL RESOURCES CONSERVATION SERVICE**  
**NORTH DAKOTA**

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## Section 1 - Preface

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### 1.1 – Introduction

The following user guide outlines the basic use of the Excel workbook to assist with the design and construction package creation of a stockwater system and/or solar powered water pump system and/or wind system. The solar powered design tool follows the guidance and design procedures outlined in North Dakota Technical Note #1 – Solar-Powered Water Systems for Stockwater Design. The final construction package will include a coversheet, pipeline profile(s), design plan and layout, construction drawings, and a set of construction specifications and operation and maintenance (O&M) plans.

Use of the design workbook is dependent on the user having a basic knowledge of pump and pipeline hydraulics as well as information contained within the NRCS-ND Conservation Practice Standards 516 – Livestock Pipeline, 533 – Pumping Plant, and 614 – Watering Facility. This design workbook is to be used to assist the designer in the computations and organization of the deliverables. The designer is the ultimate decision maker in the design process and should not rely on the design workbook to do so.

Selection of the solar pump and supporting solar panel array is typically completed by an equipment supplier hired by the agricultural producer since the daily demand, total dynamic head, and solar insolation value specified by NRCS in the design. NRCS employees, however, are expected to verify that the selected equipment was correctly chosen and installed.

This workbook is programmed to download NRCS practice specifications, O&Ms, and standard drawings from the North Dakota NRCS Engineering website; see Section 2.4 – **Initial Workbook Setup**. Internet access is necessary during the initial run of the workbook to properly set up the file save location and to download the necessary documentation needed for the final construction package.

### 1.2 – Required Information

The initial step in planning a livestock watering system is doing a thorough job of identifying the problems and collecting information. It is good practice to determine the landowner’s objectives and determine if those objectives are consistent with the purpose of the conservation practice. A major purpose of conservation practices associated with developing a livestock water system is to provide water for the distribution of grazing. A complete inventory of existing resources and conditions provides the basic information necessary to provide the landowner/producer with a competent, functional, and cost-effective design that meets the intended objectives. Asking the right questions and collecting pertinent information during the initial stages of a project will be extremely beneficial during the design process and ultimately save time during the installation phase. Information which must be obtained for a water system can vary considerably depending on the complexity of the water sources to be utilized, existing installations, and the physical size of the area being served.

Before use of the workbook the following data should be collected from the appropriate sources. Refer to the North Dakota NRCS Engineering Planning Guide for Livestock Watering for further guidance: [Engineering Planning Guides - North Dakota | Natural Resources Conservation Service \(usda.gov\)](#)

#### Resource Inventory Data:

- Producer's name, location, project or practices to be planned
- Type and # of livestock or animals and grazing or stocking dates
- Type of grazing or stocking system including travel distance to water
- Source of water supply for planned system; including source characteristics such as water surface elevation and supply rate and dependability

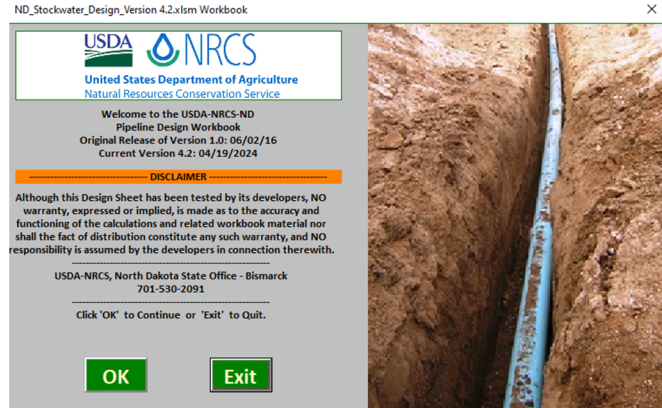
#### Pipeline Data:

- Pipeline layout
- Survey data of planned pipeline route  
Existing pipeline type, size, and route; if applicable the site-specific solar energy available (“solar insolation”).

## Section 2 – Workbook Information and Initial Setup

### 2.1 – Opening the Workbook


- a) Open the spreadsheet named:  
    **\_Stockwater\_Design\_V4.2.xlsm**
  - i. The number after the V in the workbook name reflects what version of the workbook is being used. R0 was the initial version.
- b) The Disclaimer Screen
  - i. Review the disclaimer
  - ii. Click **OK** to accept the conditions

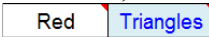


### 2.2 – Workbook Instructions

The Workbook Instruction tab contains information on the features and functions of each tab within the workbook. It also explains the overall format of the workbook and instructions for data input.

All data entry within the workbook is located in light blue cells and the user entry is blue:

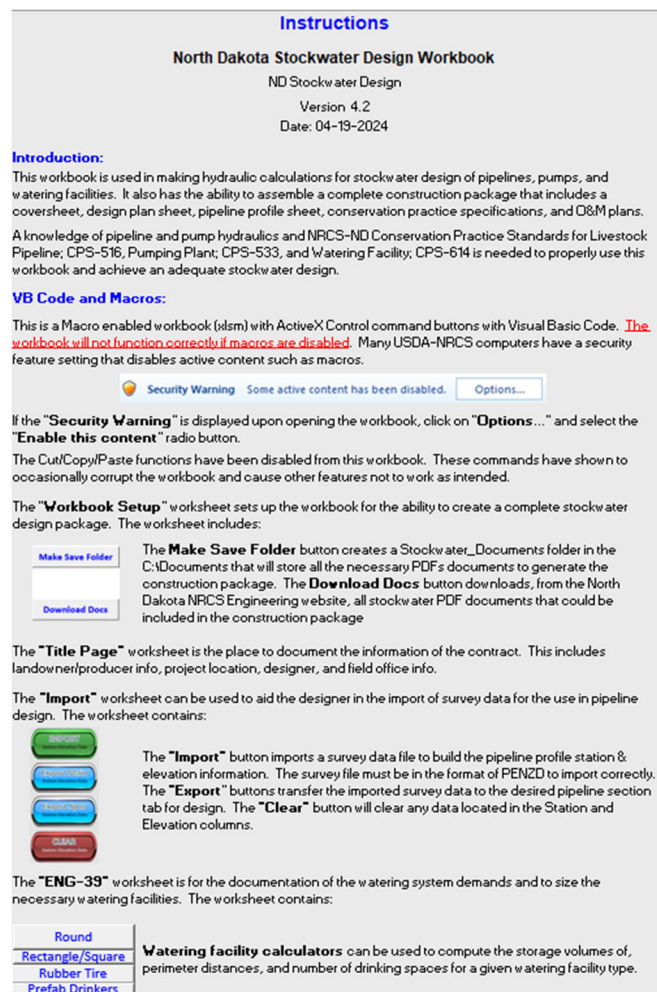
. All other cells within the workbook are locked and cannot be changed by the user.

If you have any questions during the use of the workbook, read the red flag help comments first (  ). If that doesn't answer it, refer to the Instructions tab.

If you have questions or issues with the functions of the workbook, the following person may be contacted for user support:

Cassie Ahmed  
[Cassie.Ahmed@usda.gov](mailto:Cassie.Ahmed@usda.gov)  
Bismarck SO, North Dakota  
Cell: 701-226-8620

There is additional information about the workbook in the Developer Notes tab.



**Instructions**

**North Dakota Stockwater Design Workbook**  
ND Stockwater Design  
Version 4.2  
Date: 04-19-2024

**Introduction:**  
This workbook is used in making hydraulic calculations for stockwater design of pipelines, pumps, and watering facilities. It also has the ability to assemble a complete construction package that includes a coversheet, design plan sheet, pipeline profile sheet, conservation practice specifications, and O&M plans. A knowledge of pipeline and pump hydraulics and NRCS-ND Conservation Practice Standards for Livestock Pipeline; CPS-516, Pumping Plant; CPS-533, and Watering Facility; CPS-614 is needed to properly use this workbook and achieve an adequate stockwater design.

**VB Code and Macros:**  
This is a Macro enabled workbook (xlsm) with ActiveX Control command buttons with Visual Basic Code. **The workbook will not function correctly if macros are disabled.** Many USDA-NRCS computers have a security feature setting that disables active content such as macros.

**Security Warning** Some active content has been disabled.

If the **"Security Warning"** is displayed upon opening the workbook, click on **"Options..."** and select the **"Enable this content"** radio button.

The Cut/Copy/Paste functions have been disabled from this workbook. These commands have shown to occasionally corrupt the workbook and cause other features not to work as intended.

The **"Workbook Setup"** worksheet sets up the workbook for the ability to create a complete stockwater design package. The worksheet includes:

- Make Save Folder**: The **Make Save Folder** button creates a Stockwater\_Documents folder in the C:\Documents that will store all the necessary PDFs documents to generate the construction package. The **Download Docs** button downloads, from the North Dakota NRCS Engineering website, all stockwater PDF documents that could be included in the construction package.
- Download Docs**

The **"Title Page"** worksheet is the place to document the information of the contract. This includes landowner/producer info, project location, designer, and field office info.

The **"Import"** worksheet can be used to aid the designer in the import of survey data for the use in pipeline design. The worksheet contains:

- Import**: The **"Import"** button imports a survey data file to build the pipeline profile station & elevation information. The survey file must be in the format of PENZD to import correctly.
- Export**: The **"Export"** buttons transfer the imported survey data to the desired pipeline section tab for design.
- Clear**: The **"Clear"** button will clear any data located in the Station and Elevation columns.

The **"ENG-39"** worksheet is for the documentation of the watering system demands and to size the necessary watering facilities. The worksheet contains:

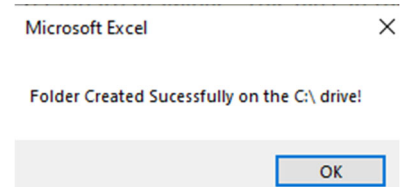
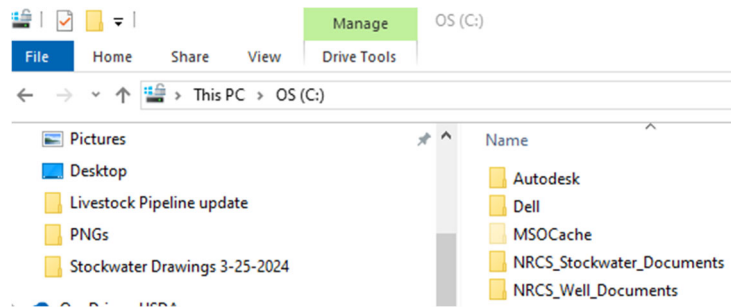
Round	<b>Watering facility calculators</b> can be used to compute the storage volumes of, perimeter distances, and number of drinking spaces for a given watering facility type.
Rectangle/Square	
Rubber Tire	
Prefab Drinkers	

## 2.3 – WorkbookSetup

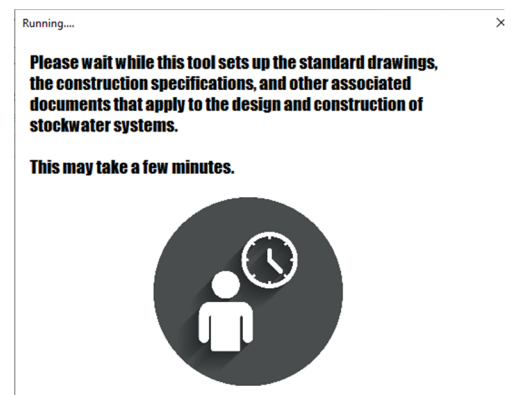
A file save location must be set up in order to store all documentation downloaded by the workbook. This is accomplished on the Workbook Setup tab. For NRCS employees that are networked into the USDA IT network, the save location is set to the user's unique Documents folder within the Libraries of Windows Explorer. An alternate file save location on the main C:\ drive is automatically set for those users who are not within the NRCS computer network. For all users, the created file folder is called NRCS\_Stockwater\_Documents.

**The following steps need only be completed for new users or setup on new computers.**

- a) Create a save folder in the file save location
  - i. Click on the **Make Save Folder** button
  - ii. Verification of successful folder creation should display. Click **OK**
  - iii. Confirm that folder has indeed been created in the appropriate location
    - Open Windows Explorer
    - Navigate to C:\
    - Folder should show to have been created



- b) Click on the **Workbook Setup** button to automatically download all the stockwater documents from the ND NRCS Engineering website. The documents include ND NRCS Practice Specifications and Operation & Maintenance (O&M) Plans for all the stockwater practices and the ND NRCS standard drawings for practice installation. It is important that an internet connection is available, or the download will not work correctly. **As versions of the documents are updated on the ND NRCS Engineering website, notification will be sent to all users of the updates and it will be necessary for the documents to be re-downloaded by the workbook.**
  - i. Be patient; the download may take several minutes to execute
  - ii. After the initial setup of the workbook there may be occasions when the documents and drawings will need to be updated. During the download for any updates you will be asked about duplicate files. When asked; please select the following options:
    - Check the box in the lower left hand corner; **Do this for the next ## conflicts**
      - Click the first option **Copy and Replace**
  - iii. A list is displayed of the ZIP files downloaded to the NRCS\_Stockwater\_Documents folder





## 2.4 – Title Page

The Title Page tab is an informational page to record who, what, when, and where information relevant to the design. This information is used to populate other cells throughout the workbook. The information copied will be locked on subsequent tabs and would need to be changed on the Title Page tab if so desired.

- a) Select from the drop down menu the design level for the project:
  - i. Planning of
  - ii. Preliminary Design of
  - iii. Final Design of
  - iv. As Build Documentation of
- b) Select from the drop down menu which of the following system components are to be designed:
  - i. Pump
  - ii. Pump and Livestock Pipeline
  - iii. Pump and Watering Facilities
  - iv. Pump, Livestock Pipeline and Watering Facilities
  - v. Livestock Pipeline
  - vi. Livestock Pipe and Watering Facilities
  - vii. Watering Facilities
- c) Enter information for the producer/landowner
  - i. Name of contract participant
- d) Select Power Type
  - i. Electric Grid
  - ii. Rural Water
  - iii. Generator
  - iv. Solar
  - v. Spring
  - vi. Wind
- e) Optional information could include address, contact info, executor of entity/estate, etc. er the legal location and county information for the project including:
  - i. Section, Township, and Range of the project location
    - Section descriptors can be included as necessary
  - ii. County where the project is located (Select from dropdown box)
    - A message box is displayed asking if the servicing field office is located in the same county as the project.
      - Select **YES** if true and the name of the field office associated with the selected county is then populated.
      - Select **NO** if false and enter the name of the field office that services the project contract.
    - If multiple offices are located within the county then select the appropriate one from the dialog box.
  - iii. Name of the Local Conservation District that services the project area location
  - iv. Name of Field Office that is servicing the project contract
    - The field office name is set as the servicing field office for the county previously selected.

The screenshot shows the title page of the 'North Dakota Stockwater Design Workbook'. At the top, it features the USDA logo and the text 'United States Department of Agriculture' and 'NATURAL RESOURCES CONSERVATION SERVICE'. Below this, the title 'North Dakota Stockwater Design Workbook' is displayed, followed by a subtitle 'PUMP, LIVESTOCK PIPELINE, & WATERING FACILITIES'. The form includes several input fields: 'for' (with a dropdown menu), 'Section:', 'County:', 'Township:', and 'Range:'. Below these is a field for 'Conservation District, North Dakota'. There are also sections for 'Prepared By:' (with a 'Field Office' dropdown), 'Planned By:', 'Planning Approved By:', 'Date:', 'Designed By:', 'Date:', 'Checked By:', and 'Date:'. At the bottom, it specifies 'Maximum Engineering Job Class: 1'.

This is a dialog box titled 'Microsoft Excel'. It contains the question 'Is servicing Field Office located in same county as project?' and two buttons: 'Yes' and 'No'.

This is a dialog box titled 'UserForm1'. It contains the text 'Please enter the servicing field office:' followed by a text input field labeled 'Field Office'. There are 'OK' and 'Cancel' buttons at the bottom.

This is a dialog box titled 'UserForm4'. It contains the text 'Select appropriate Field Office for Sioux County:'. Below this, there are two buttons: 'Fort Yates FO' and 'Selfridge FO'.

- f) Enter Planner information
  - i. Planned by:
    - This is the planner of the entire design package and who is responsible for the content there within.
  - ii. Planning Approved by:
    - This is the planner with JAA for planning of the project.
  - iii. Date
    - This is the date of when the planning was approved by the planner with JAA.
- g) Enter designer information
  - i. Designed by:
    - This is the designer of the entire design package and who is responsible for the content there within. The entered name is transferred to the rest of the design pages and drawings.
    - The person that will approve the design will sign the ND ENG 1
  - ii. Date
- h) This is the date of when the design was completed. The entered date is transferred to the rest of the design pages and drawings.
  - Enter Checker information
    - i. Checked by:
      - This is the checker of the entire design package. The entered name is transferred to the rest of the design pages and drawings.
    - ii. Date
      - This is the date of when the check was completed. The entered date is transferred to the rest of the design pages and drawings.

Maximum Engineering Job Class: will automatically be populated based on the design information

## Section 3 – Water Resource Inventory and Watering Facility Design

### 3.1 – ND-ENG-39


The purpose of the ND-ENG-39 is to document and design the water requirements of the planned livestock watering system. The ND-ENG-39 consists of two main sections; Resource Planning and Inventory and Watering Facility Sizing and Delivery Requirements.

It is good practice to start with a blank workbook for all new projects. A **Clear Data** button is available to clear out all existing data on the ENG\_39 worksheet. A message box will appear to confirm that all existing data entries will be deleted.



- a) Choose **OK** to continue deleting all existing data entries
- b) Choose **Cancel** if existing data is not to be deleted

A title block located at the top of the ND-ENG-39 form is available for documentation of the NRCS contract information. Data previously entered on the Title Page tab is automatically transferred into the title block. If any of this information needs to be changed then it is to be done on the Title Page tab.

	<b>United States Department of Agriculture</b>	<b>Clear Data</b>	ND Stockwater Design Version 4.2 North Dakota
<b>WATERING SYSTEM RESOURCE INVENTORY and WATERING FACILITY DESIGN WORKSHEET ND-ENG-39</b>			
Producer:	Farmer Bob	Field Office:	<Select Field Office>
Contract No.:		CIN(s):	
Location:	Section 1 Township 123 Range 45	Field(s) No.:	
Designed by:		Date:	
Checked by:		Date:	

- a) Select the Field office from the drop down menu
- b) Enter the Contract Number of the NRCS conservation contract
- c) Enter the Contract Item Number (CIN(s)) of items being designed and contracted
- d) Enter the Field/Pasture Number associated with each CIN within the contract
- e) Checked by & Date: Will automatically be populated from Title Page
  - i. To be completed by NRCS personnel with the experience in the type of design. The checker shall be someone other than the designer.
- f) Planned Watering System Description:
  - i. Enter detailed description of the watering system being designed. Include description and location of the water source, type and route of pipeline, type and location of watering facilities, etc. Continue the description on the back of the ND-ENG-39 (bottom of the ENG-39 worksheet) as needed.
    - Example: A new livestock pipeline is to tie into an existing well located in field 1. The well does not have an existing pump and a new pump is to be installed. The pipeline is to service fields 1 and 2 with a spur in field 2 to provide service to field 3. A total of three new fiberglass watering facilities to serve as drinking tanks; one in each field.

<b>Planned Watering System Description:</b>

### 3.2 – ND-ENG-39; Resource Planning and Inventory

As described in **Section 1.2 – Required Information**; a main purpose of the conservation practices associated with developing a livestock water system is to provide water for distribution of grazing. The design workbook utilizes the maximum daily summer drinking demands for the primary users of the watering system.

These values are shown in Table 3.1. There is limited published data on water requirements for bison; however, it is generally assumed that the daily requirements are similar if not slightly less for bison cows, calves, and bulls as it is for beef cattle.

Animal	Gal/Day
Beef - Lactating Cow and Calf	20
Beef - Bred/Dry Cow or Heifer	15
Beef - Growers (600 lb avg)	13
Beef - Yearlings/Finishers (800 lb avg)	18
Bulls	19
Dairy - Lactating Cows	25
Dairy - Dry Cows	17
Horses	18
Hogs	3
Sheep and Goats	2
Elk	8
Deer/Antelope	2
Upland Game Birds	5

**Table 3.1**

If the watering system will supply water to different species other than shown, ensure that sufficient water is provided to meet the sum of the seasonal high daily water requirements of all the animals. Design documentation is required for water requirement values not included in this design workbook.

#### Daily Water Requirements:

The **ENG-39** worksheet is set up to document up to four different species of livestock or wildlife.

Type of Livestock	Number of Livestock	Water Requirement	Daily Water Use	Required Drinking Spaces
Beef - Lactating Cow and Calf	250	x 20 gpd =	5,000 gals.	13
		x 0 gpd =	0 gals.	
		x 0 gpd =	0 gals.	
		x 0 gpd =	0 gals.	
<b>Total =</b>			<b>5,000 gals.</b>	<b>13</b>

- a) Enter the **Type of Livestock** that is to utilize the watering system
  - i. Multiple types of livestock may be selected. Several species of wildlife may be selected as well.
- b) Enter the **Number of Livestock** or wildlife for each type selected
  - i. If multiple herds or pastures are to be managed throughout the year, use the maximum number of animals that will utilize the system at one time.
- c) Review the determined **Water Requirement**:
  - i. The maximum daily summer drinking requirement for 1 animal of the selected animal type in units of gallons per day (GPD).
- d) Review the determined **Daily Water Use**:
  - i. The calculated total daily drinking requirement for each selected animal type in units of gallons.
  - ii. A grand total is calculated for the daily drinking requirements of all animal types selected. This is the value used for sizing of the watering system.
- e) Review the **Required Drinking Spaces**:
  - i. For purposes of improving grazing distributions of beef cattle herds the required number of drinking spaces have been calculated for each animal type; as per the ND NRCS conservation practice standard 614.
    - 1 drinking space per 20 animals for pasture or range units with maximum travel distance to water is in excess of ½ mile.
    - 1 drinking space per 40 animals for pasture of range units with maximum travel distance to water is less than ½ mile.
    - 1 drinking space per 100 animals for high density beef cattle operations such as feedlots, calving pens, winter feeding areas, or intensively managed grazing systems.
  - ii. A grand total is calculated for the number of required drinking spaces that is to be provided by the watering system. Note: The value depends on the selection of a grazing system type. See **Subsection g**).

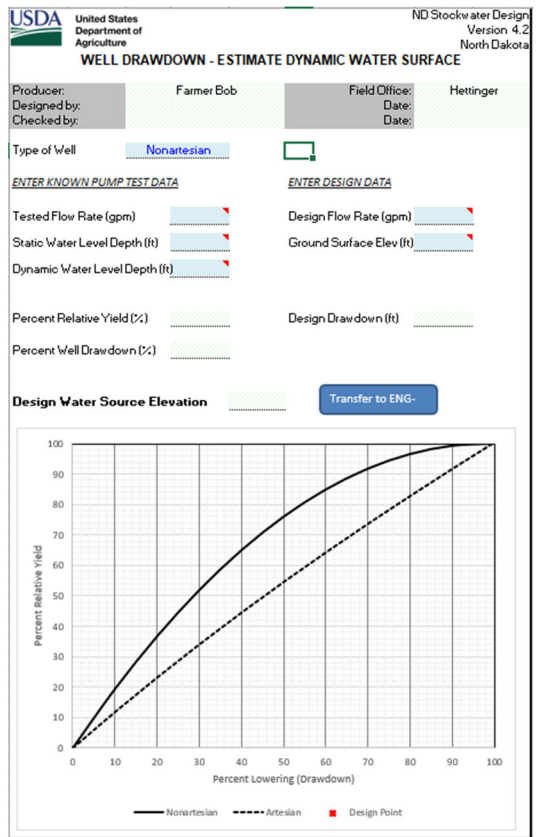
## Grazing Management and Water Source Information:

Information is to be entered for how livestock is managed and the planned source of water for the system. This is to determine the watering system requirements utilized in the design process.

Grazing Dates Livestock Utilize System: From:  to   
Type of Stocking / Grazing System:   
Water Supply Power Source:   
Source Water Surface Elevation:  ft [ND Well Data](#)   
Source Max Flow Rate:  gpm

- f) Enter the grazing dates that livestock will be utilizing the water system
  - i. Systems designed for use solely within the months of October to April may have the daily drinking requirement of the animals reduced by 50%. If additional grazing is to be managed outside these dates then the full daily drinking requirement shall be used.
- g) Choose one of the following management style of the grazing or stocking system from the drop down menu. The choice determines the required # of drinking spaces needed for each pasture or range unit and the storage requirements of the watering system.
  - i. Range/Pasture with greater than ½ mile max travel to water
  - ii. Range/Pasture with less than ½ mile max travel to water
  - iii. Lots or High Density / Intensively Managed Grazing Systems
- h) Choose from the drop down menu one of the following types of water supply power sources that provides water to the system. The choice determines the required storage needed within the watering system.
  - i. Reliable Power (e.g. Electric Grid / Generator / Rural Water)
  - ii. Solar
  - iii. Wind Power
- i) Enter the water surface elevation, in feet, of the water source
  - i. For water wells this is the dynamic or pumped water elevation in the well
    - Use the ND Well Data Link to lookup existing well on the ND Dept Of Water Resources MapService. See Appendix 4 on How to review local well logs
    - Example: The ground elevation at the well is 1,800 ft MSL and the dynamic water level in the well when the pump is pumping is 300 feet below the surface. The water surface elevation is then 1,800 minus 300 or 1,500 ft.
  - ii. For a gravity system from a trough or storage tank this is the outlet elevation of the trough or tank.
  - iii. For rural water or developed springs this is the elevation of water meter or spring box outlet; respectively.
  - iv. For surface water such as streams and ponds, it is recommended that the water surface elevation be a minimum of 5ft below the average water level in the stream/pond in order to account for evaporation and seasonal fluctuations.
- j) Enter the maximum flow rate, in gallons per minute (GPM), supplied by the water source
  - i. This could be what a water well, spring, or rural water system is capable of producing. The entered value should be supported by a system curve; as appropriate.
- k) If pump test data is available click on the calculate well button.

- l) A new tab Well drawdown will open
- m) Enter the tested flow rate, in gallons per minute (GPM), this is the flow rate that was pumped during the pump test
- n) Enter the static water level depth, in feet, this is the depth from the ground surface to the water surface at the static condition
- o) Enter the dynamic water level depth, in feet, this is the depth from the ground surface to the water surface at the dynamic condition as measured during the pump test
- p) Enter the design flow rate, in gallons per minute (GPM)
- q) Enter the Ground surface Elevation, in feet, this is the elevation of the ground at the well. This elevation will be transferred to the ENG-39 for the water source elevation.
- r) Click on transfer to ENG-39 the information will be populated in the ENG-39 tab
- s) The clear button can be used to remove all the data from this tab

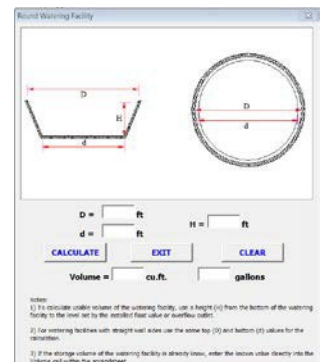


### 3.3 –ND-ENG-39; Watering Facility Sizing and Delivery

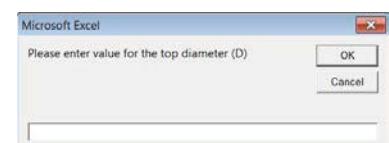
- a) Calculators are included within the **ENG-39** worksheet to aid in the sizing of several different types of watering facilities. These types include Round, Rectangle/Square, Rubber Tire, and Prefab Drinkers. For the Round, Rectangle/Square, and Rubber Tire facilities the calculators can be used to compute the perimeter and storage volume by entering the dimensions of the watering facility. For the Prefab Drinkers the minimum # of drinking spaces and # of waters needed can be computed by entering the # of animals to utilize the drinkers and the number of watering spaces provided by the desired drinker. The use of the calculators are optional. If the perimeter and storage volume values of a watering facility or the # of spaces of a drinker are already known then they can be entered directly without the use of a calculator. Click on the desired watering facility type to open the calculator
- b) Enter each dimension or value, as shown on the figure, into the appropriate boxes

The dimension for the watering facility depth (H) is the height from the bottom of the facility to the level set by a float valve or overflow outlet. On a 2ft tall tank this is typically 1.75ft. This height is used to determine the usable water volume of the facility.

- c) Click **CALCULATE** to compute the Volume or # of Drinking Spaces & Waterers
  - i. For the Round, Rectangle/Square, and Rubber Tire facilities a perimeter is computed and entered directly into the **ENG-39** worksheet as well.
  - ii. If a required entry was left blank and the Calculate button is clicked then an input box will appear.
    - Enter the desired value
    - Click **Enter** to have the value placed into the calculator



- d) To clear the calculator click the **CLEAR** button
- e) Click **EXIT** to return to the **ENG-39** worksheet



After use of the watering facility calculators, the computed values are automatically populated into the **ENG-39** worksheet. If the computed values need to be adjusted or if the values are already known then they can be manually entered.

Watering Facility Type:	Perimeter	Volume	# of Facilities	Actual Drinking Spaces Per Tank
Round	16 ft	254 gals	1	16
Rectangle/Square	ft	gals	0	
Rubber Tire	ft	gals	0	
Prefab Drinkers	Min. Drinking Spaces:	# of Spaces per Waterer:		
<b>Total Watering Facility Volume (WFV) =</b>				<b>254 gals.</b>
				<b>16</b>

- f) Enter the # of Facilities of each type of watering facility desired
- g) Total Watering Facility Volume (WFV):
  - i. The volume is in units of gallons.
  - ii. A grand total of the volume is calculated for all entered watering facilities in Cell R36.
- h) Actual Drinking Spaces per Tank:
  - i. The actual # of drinking spaces is calculated from the watering facility perimeter and the spacing requirements based on the watering facility shape.
    - For round or rubber tire facilities; allow 12-inches per animal.
    - For rectangle/square facilities; allow 18-inches per animal.
  - ii. The number of spaces computed is for a single tank of the selected type.
  - iii. This value is compared to the Required Drinking Spaces previously calculated.
    - If the value is less than the required value then a warning message appears in red.
- i) Total Daily Water Use (WU):

Total Daily Water Use (WU): Use 10% for evaporation and spillage?  Yes

WU = Daily Water Use + 10% Added for Evaporation and Spillage  
 WU = 5,000 x 1.1 = 5,500 gals. / day

- i. The Total Daily Water Use (WU) is based on the entered animal numbers and the type of stocking and grazing system.
- ii. For watering facilities with surface areas over 20 square feet it is recommended to account for an additional 10% of water volume for losses associated with evaporation and spillage.
  - Choose YES from the drop down menu if this true
    - Daily Water Use is multiplied by 1.1

**Delivery Rate:**

The volume and rate of delivery for the watering system needs to be sufficient, practical, and feasible. The minimum design flow rate for the watering system shall be based on providing the peak daily water requirements for the maximum planned herd size within 12 hours. When the flow delivery period exceeds 12-hrs per day, the combination of additional water storage and the design water delivery flow rate may be used to provide the maximum daily need within 12-hrs. In addition, systems that deliver to watering facilities with less than 10 sq.ft. of open water, such as prefabricated waters/drinkers, it is recommended that the minimum design flow be based on 2 gpm per drinking space accessible to the herd at a single point in time. It is often desirable to design for a higher flow rate to allow the watering facilities to refill more rapidly during times of peak usage. The flow delivery period will depend on the flow available at the water source, the size of the herd, length of the watering system, and any domestic use that may be needed.

Water Source Also Provide Domestic Use?

12-Hour Watering System Flow Rate (Q<sub>12</sub>): Q<sub>12</sub> = WU / (12hr/day \* 60) = \_\_\_\_\_ gpm

Design Water Delivery Flow Rate (Q): \_\_\_\_\_ gpm      Flow Delivery Period: \_\_\_\_\_ hr/day

Minimum Pump Flowrate (Q<sub>pump\_min</sub>): \_\_\_\_\_ gpm

Design Pump Flow Rate (Q<sub>pump</sub>): \_\_\_\_\_ gpm

- j) Determine if any domestic use is to be provided
  - i. Select **Yes** or **No**
    - If Yes is selected then provide a minimum of 10 gpm per household for water sources that supply domestic use in addition to livestock/wildlife.
      - Enter the # of Households to be provided water

- k) 12-Hour Watering System Flow Rate (Q<sub>12</sub>):

- i.  $Q_{12}$  is calculated by dividing the total daily water use (WU) by the minimum 12 hr/day delivery period.
- l) Enter the desired Design Watering System Flow Rate (Q)
  - i. This value is compared to the source water max flow rate.
    - If the value is less than the source max flow rate then a warning message appears in red.  
\* Design flow rate exceeds the max flow rate of the water source!
  - ii. This value is used, in part, to determine any required storage and in the design of the watering system pipeline.
  - iii. When Q is less than  $Q_{12}$ , water storage shall be provided so that the daily watering need of the animals within a 12-hr period. When this is true then a message appears in blue.  
\*  $Q < Q_{12}$ : See Required Storage (RS) and Additional Storage (AS<sub>min</sub>) for storage needed.
  - iv. For systems supplying water through prefabricated waterers/drinkers and the design watering system flow rate is at least 2 gpm per required drinking spaces then a notification message appears in green.  
\* A flow rate of 2 gpm per drinking space has been met and may be used as a substitute for storage.
    - Example: The determined # of required drinking spaces is 7. At 2 gpm per drinking space the minimum design flow rate would need to be 14 gpm.
  - v. For systems supplying water to lots or high density / intensively managed grazing systems it is recommended that water be delivered at a rate of 2 gpm per drinking space. When the Q flow rate is less than the value of 2 gpm per drinking space then a warning message appears in red.  
\* Design Watering System Flow Rate (Q) < the Number of Required Drinking Spaces x 2 gpm!
- m) Flow Delivery Period:
  - i. Based on the entered designed watering system flow rate.
  - ii. When the flow delivery period exceeds 24-hrs, the daily watering requirements of the animals cannot be met. If this is the case then a warning message appears in red.  
\* Inadequate Design: Design Delivery Period > 24-hrs!
- n) Minimum Pump Flowrate ( $Q_{pump\_min}$ ):
  - i.  $Q_{pump\_min}$  is determined from the larger of the  $Q_{min}$  and the value from domestic use needs; if applicable.
- o) Enter the desired Pump Flow Rate ( $Q_{pump}$ ):
  - i. This value is compared to the  $Q_{pump\_min}$  previously determined.
    - If the value is less than  $Q_{pump\_min}$  then a message appears in blue. \*  $Q_{pump} < Q_{pump\_min}$
  - ii. This value is used in the design of the pumping system.

### Storage Requirements for reliable power sources:

\*For solar powered requirements see Storage Requirements for Solar Powered systems section  
Storage requirements for the watering facilities shall have a minimum volume in order to provide adequate water to the livestock/wildlife between periods of replenishment. The required storage volume is based on the source of water, design flow rate, location, and the type of stocking/grazing system. Storage can also be used to compensate for low flow. The combination of the storage volume and the design water delivery flow rate can be used to provide the maximum daily need within 12-hrs.

Required Days of Storage in Pasture ( $DS_{min}$ ):	1	day(s)	Design (DS):	1	day(s)	*
Required Storage in Pasture (RS):	$RS = DS \times WU - \text{Inflow} = 1 \times 5,500 - 2,880 = 2,620 \text{ gals.}$					
Required Additional Storage ( $AS_{min}$ ):	$AS = RS - WFV = 2,366 \text{ gals.}$					
Design (AS):	$2,400 \text{ gals.}$					



- p) Required Days of Storage in Pasture ( $DS_{min}$ ):
- $DS_{min}$  is determined based on the following criteria:
    - For watering facilities supplied by reliable power:
      - 1 day storage minus 6hrs of inflow for Range/Pasture with greater than ½ mile max travel to water
      - ½ day storage minus 1hr of inflow for Range/Pasture with less than ½ mile max travel to water
        - A flow rate of 2gpm per required drinking space may be used as a substitution for storage
    - For watering facilities supplied by solar or wind power: 3 days storage
    - For watering facilities installed for feedlots, winter feeding areas, calving pens, and intensively managed grazing systems:
      - No minimum storage is required. The requirements for those areas shall be based solely on perimeter access and a flow rate of 2gpm per drinking space accessible to the herd at a single point in time.
- q) Enter the Design Days of Storage ( $DS$ ) for the watering system
- If the  $DS$  value is less than  $DS_{min}$  then a warning message appears in red.  
\* Min. days of required storage not met!
- r) Required Storage in Pasture ( $RS$ ):
- $RS$  is the product of the design days of storage ( $DS$ ) and the total daily water use ( $WU$ ) minus any inflow as determined from the required days of storage ( $DS_{min}$ ) criteria.
- s) Required Additional Storage ( $AS_{min}$ ):
- $AS_{min}$  is the difference between the required storage in the pasture ( $RS$ ) and the total watering facility volume ( $WFV$ ).
  - Additional storage may be required if the required storage ( $RS$ ) is greater than what has been planned in the sizing of the watering facilities;  $WFV$ .
- t) Enter the additional storage ( $AS$ ) needed
- If the value is less than  $AS_{min}$  then a warning message appears in blue.  
\* Min. additional storage not met: Consider providing more volume in the watering facilities, design a storage tank, or increase system flow rate.
  - A check is made to determine if the volume of the designed additional storage ( $AS$ ) can be supplied by the design delivery flow rate ( $Q$ ) within the designed days of storage ( $DS$ ). A warning message is displayed in red when the  $AS$  volume is larger than what  $Q$  can supply.  
\* Delivery > 24hr; NOT FEASIBLE!

### Storage Requirements for Solar Powered System:

In North Dakota, NRCS requires 3 days of storage be supplied by a solar powered system. The storage can be a combination of drinking tanks and/or storage tanks.

Required Days of Storage in Pasture ( $DS_{min}$ ):	3	day(s)	Design ( $DS$ ):	3	day(s)	*
Required Storage in Pasture ( $RS$ ):	$RS = DS \times WU = 3 \times 1,000 = 3,000$ gals.					
Required Additional Storage ( $AS_{min}$ ):	$AS = RS - WFV = 2,000$ gals. *					
	Design ( $AS$ ) = 2,500 gals.					

- a) Required Days of Storage in Pasture ( $DS_{min}$ ):
- $DS_{min}$  is determined based on the following criteria:
    - For watering facilities supplied by solar power:
      - 3 days storage
- b) Enter the Design Days of Storage ( $DS$ ) for the watering system
- If the  $DS$  value is less than  $DS_{min}$  then a warning message appears in red.  
\* Min. days of required storage not met!
- c) Required Storage in Pasture ( $RS$ ):
- $RS$  is the product of the design days of storage ( $DS$ ) and the total daily water use ( $WU$ ).  
Example:  $RS = DS \times WU = 3 \times 1,000 = 3,000$  gallons.

- d) Required Additional Storage ( $AS_{min}$ ):
  - i.  $AS_{min}$  is the difference between the required storage in the pasture (**RS**) and the total watering facility volume (**WFV**).  
 Example:  $AS = RS - WFV = 3,000 - 1,000 = 2,000$  gallons
  - ii. Additional storage may be required if the required storage (**RS**) is greater than what has been planned in the sizing of the watering facilities; **WFV**.
- e) Enter the additional storage (**AS**) needed
  - i. If the value is less than  $AS_{min}$  then a warning message appears in blue.  
 \* **Min. additional storage not met: Consider providing more volume in the watering facilities or design a storage tank–**

### 3.4 ND-ENG-39; Existing Water Sources and Documentation

A complete inventory of existing resources and conditions is needed to provide justification for the watering system that is being planned. Some information may include the location and details of the existing water sources (i.e. quality and reliability) in the areas to be serviced by the new watering system.

Field No.	Existing Water Sources	Dependability/Quality

- u) Enter the following information for any existing water sources available to the livestock/wildlife in the area to be serviced by the new watering system:
  - i. Field Number where the existing water source is located
  - ii. Type of Existing Water Source; i.e. pond, creek, wetland
  - iii. Dependability/Quality of the existing water source

Use of design notes are an essential part of documenting the decisions that are made during the design process. A design note section is available on the back of the ND-ENG-39 (bottom of the ENG-39 worksheet) for extra documentation as needed.

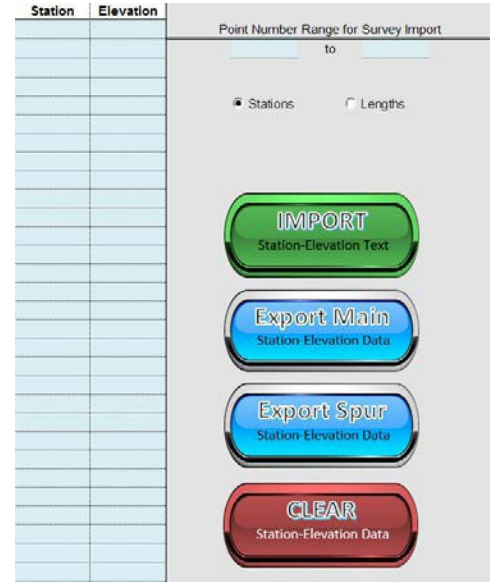
ND-ENG-39 (Back)
Planned Watering System Description (Continued):
Design Notes:

## Section 4 – Survey Data Import

### 4.1 – Survey Data Entry

The Import tab of the design workbook can be used to assist with the entry of pipeline data. The values used to represent the profile of livestock pipelines are “Station” and “Elevation”. Station is the cumulative distance to a point within a profile. Elevation is the elevation of the natural ground at the corresponding station. The Import tool also allows for the entry of “Lengths” when entering pipeline profile data. Length refers to the distance between the points within the profile. These lengths are then converted into stationing. Pipeline survey data can either be entered directly into the Import tab by manual entry or by importing a survey data file. See **Section 4.2 – File Import** to import a survey data file.

- a) Select either **Stations** or **Lengths** to begin the entry of pipeline data
  - i. For manual entry, directly enter the pipeline survey data.
    - Data for any spurs lines are to be entered independently and separate from the main section of the pipeline.
  - ii. The “Lengths” option cannot be used when importing pipeline survey file. The **IMPORT** button becomes invisible with selection of the “Lengths” option.
    - When entering lengths, the first length is to be 0 in order to set the first station as Station 0+00. The remaining lengths are then used to set the remaining stations.



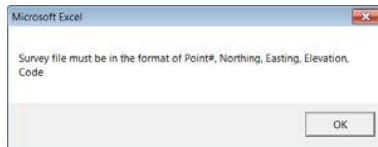
### 4.2 – File Import

To utilize this feature the file to be imported must be either a .txt or .csv file. The survey file must be in the format of PNEZD (Point, Northing, Easting, Elevation, Description). The file may either be space, tab, or comma delineated. The point numbers of the survey file must begin with a number other than 0 and not include duplicate point numbers. A survey file can include multiple pipeline profiles. These may include the main section of the line and several spurs or tees. Shots representing the pipeline profiles are to be in sequential order to utilize the Import feature. Before a file is imported, an option is available to select a range of points that is unique to the section of pipeline desired for export. When the file is imported, the entire file is loaded but only those shots with the point numbers entered are used. Each subsequent pipeline section is to be imported and exported separately.

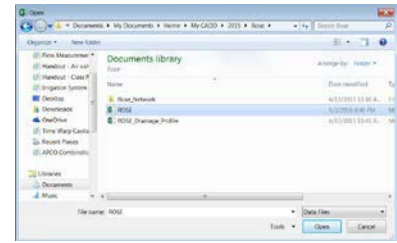
- a) Enter the point range for the points to be exported to the pipeline design tabs
  - i. If the range is left blank then the entire survey file is selected for export.



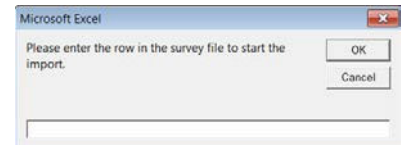
- b) Click the **Import** button
  - i. A dialog box appears reminding of the required file format of PNEZD. Click **OK**



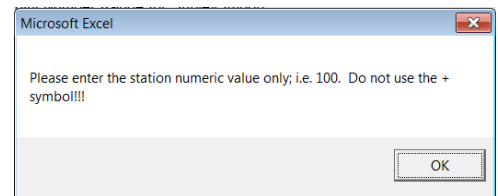
- ii. A Windows Explorer opens
  - Navigate to the folder location of the desired survey file to import
  - Select the survey file to import
    - Click **Open**



- c) A dialog box appears asking to enter the row in the survey file to start the import
  - i. Some survey files may include a header above the survey data. This is not desired input. In addition, the first few shots in the survey may be base station or temporary benchmark shots that are related to the pipeline survey. These shots are typically not a part of the pipeline profile and need to be excluded from the file import.
  - ii. Enter the row number that the pipeline profile data starts
    - Caution: This entry is not a point number.
  - iii. Click **OK** to complete the import



The imported file is processed and stationing is calculated for the point number range that was set previously in **Step a)** of **Section 4.2 – File Import** along with the associated station elevation. The first station of the imported data is set as Station 0+00. The data can be manipulated as needed after it has been imported and before being exported into the pipeline design tabs. The station and elevation data may also be manually entered in lieu of importing a survey file if desired. Manual entry of stationing must be numeric. Do not use the + symbol; i.e. 1+00, when entering the station value. The station cells are formatted to convert the value to the stationing format. A message will appear if anything other than a numeric value is entered and will delete the entry.



### 4.3 – Export Data for Pipeline Design

The imported data can be exported to the desired pipeline section for design. There are two Export features available; one for the Main Line and one for the Spur Lines.

- a) Click the **Export Main** button to transfer the pipeline profile data as the main line
  - i. The profile data is now located in the Main tab
- b) Repeat **Step a)** through **Step c)** in **Section 4.2 – File Import** for each Spur section of the pipeline as needed
- c) Click the **Export Spur** button to transfer the spur profile data to the desired spur line
  - i. A dialog box appears asking to enter the Spur # to transfer the profile data to.
    - Enter only the number of the current spur to be export to; i.e. 1, 2, 3, 4, or 5. Up to 5 spurs can be entered into the workbook.
  - ii. Click **OK** to begin the transfer
  - iii. The spur data is now located in the corresponding Spur tab(s)



### 4.4 Note: The Spur tab(s) remain hidden until spur data is exported.–Clear Data

- a) Click the **Clear** button to delete all existing station and elevation data previously imported or manually entered
- b) All data should be cleared before import or entry of additional data



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## Section 5 – Livestock Pipeline Design

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### 5.1 – Hydraulic Basics

Pipeline design requires an understanding of the basic hydraulic relationships between head, pressure, flow, pipeline length, and friction loss. Simply put, pipeline flow is based on a balance of the energy applied to the system (**energy head**) and the losses the system experiences on the way to the outlet (**head losses**). The design of a stockwater pipeline system is to ensure that the desired flow rate is delivered to the outlet.

To provide the desired flow rate, a required energy head must be determined that will overcome all losses. Head can be in the form of pressure (such as those provided by pumps) or difference in elevation. The higher the pressure or the greater the elevation difference from the source to the outlet, the more energy the system has. The two main types of head used in pipeline design are **static head** and **operating head (dynamic head)**. Static head is the total energy in the system when no water is flowing. This could be the maximum pressure produced by a pump for a given flow or the maximum water elevation in a storage tank. The operating head is the energy within the system during flow conditions. It is represented by the hydraulic grade line (**HGL**). The HGL indicates the remaining head within the pipeline as it flows. If a vertical tube was inserted into the pipeline at any location along its length, the height to which the water rose would be the location of the HGL at that point. Another type of head commonly referred to is total dynamic head (**TDH**) or total system head. TDH is the total head required of the system to overcome all losses. TDH includes any elevation and/or pressure heads, all head losses, and any given clearance head.

The main type of head loss in a pipeline system is from the friction created as water flows through a length of pipe; known as **friction loss**. As a result, friction loss of a pipeline is directly proportional to its length. In addition to length, increases in flow for a particular size of pipeline or decreases in pipe size for a given flow can cause friction losses to increase. Friction loss is typically expressed in terms of feet of friction per 100 feet of pipe (ft/100ft). To show greater detail between each station in the profile of the pipeline this design workbook expresses the friction loss in terms of feet of friction per foot of pipe (ft/ft). The calculation of friction loss is based on the Hazen-Williams formula. The formula utilizes a friction loss coefficient; C. A “C” factor of 150 is used for PE, HDPE, and PVC pipe. The rate of friction loss through the pipeline is represented as the slope of the hydraulic grade line; HGL. When designing a pipeline, it is important to know the type of pipe to be used. Pipe is either Inner Diameter Controlled (ID) or Outer Diameter Controlled (OD). All ID pipe of a given diameter, i.e. 2”, have the same inside diameter. The outside diameter of ID pipe is dependent of the pipe wall thickness. Likewise, OD pipe of a given diameter, i.e. 2”, have the same outside diameter. The inside diameter of OD pipe is dependent of the pipes wall thickness. As thickness of a pipe increases, the resulting pressure rating of the pipe increases as well. Due to differing internal cross-sectional area and differing friction loss factors, friction loss in long pipelines can differ considerably from one type of pipe to another.

A profile of ground elevations along the pipeline route is vital in determining how the elevation changes along the path affect the operating head and the entire design. At a minimum, the pipeline profile should consist of stations and elevation for the key points along the pipeline length such as the water source, outlet locations, undulating highs and lows, pipeline tees, etc. High points throughout the pipeline profile, along with the pipeline length, are considered to be **control points** and can directly affect the head required to operate the system. To account for other losses in the system (known as minor losses), discrepancy in survey data, and to provide a factor of safety, the HGL should clear the centerline of the pipe by a certain **clearance head** at the most critical control point. A default clearance head of 24.5ft (≈10psi) is used within the design workbook when calculating the pipeline design.

The manner in which a system operates depends not only of the performance characteristics of the source; i.e. pump, storage tank, rural water, spring, etc., but also on the characteristics of the system that it will operate in. The performance of the source is generally represented by a curve and is the relationship between the flow rate and the hydraulic losses in the system. Since head loss is a function of flow, size and length of pipe, and minor losses, each pipeline system also has its own characteristic curve. This characteristic curve is known as the **system curve**. The system curve represents the relationship between the flow rate and the total system head required to run the system. The intersection between the source curve and the system characteristic curve is called the **operating point**. It is the point where the source will operate within the system.

Pipelines are to be designed to operate within certain conditions. When operating at design capacity, the full-pipe flow velocity should not exceed 5 ft/sec in order to minimize damage caused by **water hammer**. Water hammer is a condition that occurs when a valve rapidly shuts causing a pressure wave to reverberate back through the pipeline. This pressure wave can cause high transient surge pressures that are greater than the static pressures of the system. The design workbook gives an alert when the pressure rating value of the pipeline is exceeded.

### 5.2 – Types of Pipeline Systems

There are several types of livestock pipeline systems that can be modeled in the ND\_Stockwater\_Design workbook.

- Pumped/Pressure – Automatic (Pressure Tank)
- Pumped/Pressure – Manual (Timer)
- Gravity
- Rural Water/Pressure
- Spring Flow

The design workbook is set up to model up to 10 spurs/tees in addition to the main line of the pipeline system. For pumped systems, each spur has the option to be modeled either as a continued pumped system from the mainline or a gravity flow from a pumped mainline.

### 5.3 – Pipeline Design; Main Line

The Main tab of the design workbook models the hydraulics of the main stem of the pipeline system. It is common practice that the main stem be the longest length or the hydraulically most critical section of the pipeline system. The pipeline profile information can be manually entered or it may be imported with use of the Import tab; see **Section 4 – Survey Data Import**.

**Stockwater Pipeline Hydraulic Computation Worksheet**

Producer: Farmer Bob  
 Line: Main

Pumped     Gravity     Pressure Reducer     Booster Pump  
 Rural     Spring

Total Dynamic Head (ft) = \_\_\_\_\_  
 Source Water Surface (ft) = \_\_\_\_\_  
 Avg Burial Depth (ft) = \_\_\_\_\_  
 # of Spurs off Main Line = 0

DSN BY: \_\_\_\_\_  
 DATE: \_\_\_\_\_  
 CHECKED: \_\_\_\_\_  
 DATE: \_\_\_\_\_

Station ft.	Length ft.	Ground Elev ft.	Pipe Data		Flow gpm	Pipe Rating	I.D. inches	c	Friction ft./ft.	Line Friction ft.	PRD Fall-off psi	HGL elev.	SGL elev.	Vel ft./sec.	Working Head ft.	Working Pressure psi	Static Pressure psi	Comments	
	0		Size	Material														Pump	

- a) Enter the description of the main line in Cell B3; the default is set to “Main”
- b) Select the radio button of the type of system to be modeled
  - Pumped     Gravity
  - Rural     Spring
- c) Enter the **Source Water Surface/Existing Ground Elevation** in Cell R1
  - i. The value is copied over from the ENG-39 worksheet, if previously entered
    - See **Section 3.2 i)**
- d) Enter the **Average Burial Depth** of the pipeline in Cell R3
- e) Enter the pipeline profile stations and ground elevations if not imported previously from the Import tab
  - i. Ensure that the pipeline data table is scrolled to the top and row 10 is visible before entering data.
  - ii. A slope length along the ground surface is calculated between each station.
- f) Enter the size and type of material of the pipeline being modeled
  - i. Ensure that the pipeline data table is scrolled to the top and row 10 is visible
  - ii. A message appears if the selected pipe size does not have a corresponding pipe material.
  - iii. Click **OK** and reselect a valid pipe size and material.
  - iv. The pipeline size, material, and flow rate is only required at the beginning station of the pipeline profile unless one of those pipeline components change within the run of the line.
  - v. See **Appendix 1** for a pipeline table with data for all the pipe types supported by the workbook.



- g) Enter the desired flow rate for the pipeline design run
  - i. The value is typically the Design Water Delivery Flow Rate (**Q**) determined in the ENG-39.
    - See **Section 3.3 I**
- h) The remaining pipeline design values are calculated and include pipe pressure rating, pipe ID, C coefficient value, pipeline unit friction loss, pipeline friction loss between stations, HGL elevation, SGL elevation, pipeline velocity, working head (ft), working pressure (psi), and static pressure (psi).
  - i. If these values do not populate ensure that all required information from **Sections 5.3 b) – g)** have been entered correctly.
- i) Comments can be entered for each station of the pipeline starting in Cell S12. These can include design specific requirements for a particular station or the location of special features.
- j) Run appropriate design (Based on selection from step in **Section 5.3 b)**)

- i. Pumped

- Click the **TDH** button

- A Total Dynamic Head (TDH) is calculated for the system based on the entered flow rate and recommended clearance head.



- ii. Gravity

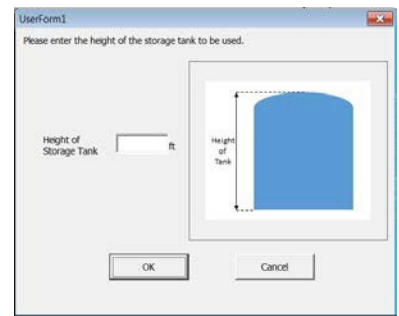
- Click the **Tank Elev** button

- If the height of the tank has not been manually entered, a box appears asking to “Please enter the height of the storage tank to be used.”
    - This is the maximum height of water in the storage tank at the float or overflow.
    - Enter the planned or existing Height of the Storage Tank and click **OK**



- A Tank Stand Height is calculated for the system based on the entered flow rate and recommended clearance head.

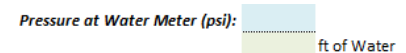
- This is the elevated height of the bottom of the tank above natural ground.



- iii. Rural

- A cell appears to enter the **Pressure at Water Meter (psi)**

- Enter the known pressure set at the water meter or at the connection of the main rural water line in units of PSI.
    - The entered value is converted into feet of water



- Enter the converted value into the **Head at Water Meter (ft)** in Cell R1

- iv. Spring

- Enter the **Head at Spring (ft)** in Cell R1

- Normally this value is 0 and is representative of the water level in the spring box being at natural ground elevation.
    - A negative value represents the depth to the water in the spring box from the natural ground elevation.
    - A positive value represents artesian flow conditions and can be determined by the height of water raised above the natural ground at the spring box.

- v. Solar: See Section 7 for designing a solar system

- k) A pressure reducer or booster pump can be added to the system as needed by clicking the appropriate check box.

Pressure Reducer     Booster Pump

- i. **Pressure Reducer**

- Cells appear to enter the **Reducer Info**

- Enter the value of the station where the pressure reducer will be installed
    - Enter the pressure setting of the reducer in units of PSI
    - The system working pressure is reduced to the value of the reducer starting from that location.



- Enter a PRD Fall-off pressure loss (psi) at the pipeline station where the pressure reducer is planned.
  - This is the pressure loss through the pressure reducer during flow.
  - Data sheets are available through the manufacture of the value that can be used to determine the pressure loss for a given flow rate.

**ii. Booster Pump**

- Cells appear to enter data for the **Booster Pump**

Station	Pressure
<b>Booster Pump:</b>	

  - Enter the value of the station where the booster pump will be installed
  - Enter the hydraulic pressure rating of the booster in units of PSI
  - The system working pressure is increased to the value of the pressure added by the booster starting from that location.

### 5.4 – Pipeline Design; Spur Lines

The design workbook can model up to 10 spurs off the main stem of a pipeline. The spur profile information can be manually entered or it may be imported with use of the Import tab; see **Section 4 – Survey Data Import**.

- a) From the Main tab use the dropdown to select the **# of Spurs off Main Line**
  - i. This is already populated if spur data was exported from the Import tab.
 

<b># of Spurs off Main Line =</b>	1	▼
-----------------------------------	---	---

    - Spur tab(s) now appear along the bottom bar of the workbook. These are already visible if spur data was exported from the Import tab.
- b) Select the desired Spur tab
- c) Enter the description of the Spur line in Cell B3; the default is set to “Spur (#)”
- d) Select the radio button for the condition the spur is to be modeled (if applicable)
 

Pumped     Pumped/Gravity

  - i. These options are only available when the Main line is modeled as Pumped
  - ii. Pumped – Spur is modeled as a continuous pumped system from the main line continuing through the spur line.
  - iii. Pumped/Gravity – The main line is a pumped system. The spur is modeled as a gravity line from a tank or storage at the tie-in of the main line.
- e) Select the **Station from Mainline** from the dropdown in Cell R2 that the Spur line ties into
- f) Enter the **Average Burial Depth** of the pipeline in Cell R3
- g) Enter the pipeline profile stations and ground elevations if not imported previously from the Import tab
  - i. Ensure that the pipeline data table is scrolled to the top and row 10 is visible
  - ii. A slope length along the ground surface is calculated between each station.
- h) Enter the size and type of material of the pipeline being modeled
  - i. Ensure that the pipeline data table is scrolled to the top and row 10 is visible
  - ii. A message appears if the selected pipe size does not have a corresponding pipe material.
  - iii. Click **OK** and reselect a valid pipe size and material.
  - iv. The pipeline size, material, and flow rate is only required at the beginning station of the pipeline profile unless one of the pipeline components change within the run of the line.
  - v. See **Appendix 1** for a pipeline table with data for all the pipe types supported by the workbook.
- i) Enter the desired flow rate for the pipeline design run
  - i. The value is typically the Design Water Delivery Flow Rate (**Q**) determined in the ENG-39 worksheet.
    - See **Section 3.3 I)**



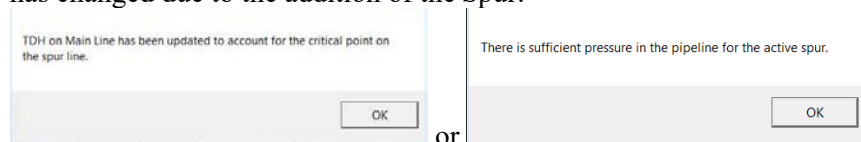


- j) The remaining pipeline design values are calculated and include pipe pressure rating, pipe ID, C coefficient value, pipeline unit friction loss, pipeline friction loss between stations, HGL elevation, SGL elevation, pipeline velocity, working head (ft), working pressure (psi), and static pressure (psi).
  - i. If these values do not populate ensure that all required information from **Sections 5.4 d) – i)** have been entered correctly.
- k) Comments can be entered for each station of the pipeline starting in Cell S12. These can include design specific requirements for a particular station or the location of special features.
- l) Run appropriate design (Based on selection from step in **Section 5.4 d)**
  - i. Pumped

- The value for HGL Elevation in Cell R1 is populated with the HGL elevation calculated of the spur tie-in station from the Main tab.
- Click the **TDH** button



- The Total Dynamic Head (TDH) is recalculated for the Main line based on the hydraulic data of the spur line.
- A one of two message appears explaining if the TDH requirement of the system has changed due to the addition of the Spur.

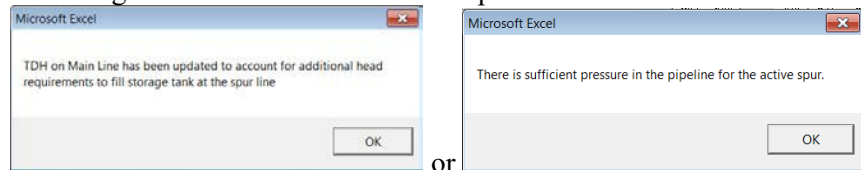
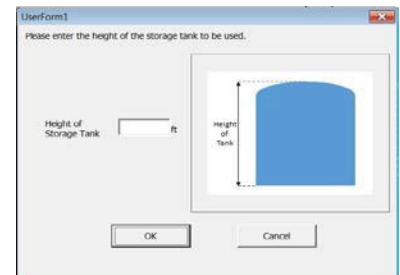


- The HGL Elevation in Cell R1 is updated as necessary to show the final HGL elevation of the spur tie-in station.



ii. Pumped/Gravity

- Click the **Tank Elev** button
  - If the height of the tank has not been manually entered, a box appears asking to “Please enter the height of the storage tank to be used.”
  - This is the maximum height of water in the storage tank at the float or overflow.
  - Enter the planned or existing Height of the Storage Tank and click **OK**
  - A Tank Stand Height is calculated for the Spur and the Total Dynamic Head (TDH) is recalculated for the Main line based on the storage tank data and the hydraulic data of the spur line.
  - A one of two message appears explaining if the TDH requirement of the system has changed due to the addition of the Spur.



iii. Gravity, Rural, or Spring

- The value for HGL Elevation in Cell R1 is populated with the HGL elevation calculated of the spur tie-in station from the Main tab and the hydraulics of the Spur is automatically calculated.
  - Review the Spur line Working Head and Working Pressure to ensure that there are no negative values (no flow).
  - Adjust design value on the Main tab as necessary.



---

## Section 6 – Design of Pumping Plant and Pressure Systems

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### 6.1 – Pump and Pressure System Basics

There are many kinds of pumps that can be used in conjunction with stockwater pipelines. The kind which will work best depends on available sources of power, flow rate, head requirements, and water source. Availability of electric power is frequently a major factor in determining whether or not an electric pump can be used. If power is not already available at the water source, it can be very expensive to bring power in. When planning a stockwater system requiring a pump, the first two things to consider are electric power availability and the cost of bringing in electric power to the site.

Proper pump sizing is determined from the principle that the pump should be able to supply the design flow rate at the maximum required operating head of the system; commonly referred to as **total dynamic head (TDH)**. Simply calling for a 1HP pump is inadequate and can lead to undesired system operation. There are many different pumps for the same size motor. One 1 HP pump may pump large quantities of water at very low heads while another may pump only a small quantity of water at very high head. All pumps share a common characteristic relating to TDH and volume (gpm). As the pressure (TDH) increases, the volume pumped decreases. This is typically depicted by pump curves that are unique to each pump. Pump curves generally contain several pumps of different horsepower that all deliver approximately the same volume. For example, a Goulds Model 5GS pump will produce around 5 GPM when operating near best efficiency over a horsepower range of ½ HP to 2 HP. The operating characteristic of a pump is determined by the intersection on the pump curve of the TDH requirements of the system and the corresponding volume produced. Therefore, to evaluate if a pump meets the design requirements, the pump curve for the installed pump must be obtained from the pump installer.

There are several considerations to keep in mind when sizing a pump:

- Is there possible future expansion needs or any additional demands the current system is supplying?
- How long will the pump be expected to run to supply the water demands of the system? The pump should not have to run nearly 24 hours to provide the daily needs.
- An oversized pump can cause excessive cycling and shorten the life of the pump.
- Pump capacity should not exceed the flow rate or yield of the water source. This can cause cycling of the pump due to low flow or no flow caused by the low water levels at the source.

A common type of pressure system is the automatic pressure system. An automatic pressure system is a pumped system which uses a pressure switch and pressure tank to control the operation of the pump. There is a common misconception that a pressure tank controls the operation of a pipeline system. The purpose of the pressure tank is to control pump cycling and limit rapid on/off cycles which can cause pump overheating and lead to premature pump failure. The operation of a pressure tank is based on the fact that air can be compressed but water cannot. When water is used in the system, the air expands to push a small amount of stored water out of the tank. As a result, the air volume increases as the tank pressure drops. When the pressure drops to equal the low setting on the pressure switch, the pump kicks on. This is referred to as the **cut-in pressure** and is commonly set by the TDH requirements of the pump. The pump runs and delivers flow to the point of usage on the system. As the system discharges through the outlet, the balance of flow begins to refill the pressure tank. As the tank fills, the air is compressed and the pressure rises. When the pressure equals the high setting on the pressure switch, the **cut-out pressure**, the pump shuts off. The difference between the cut-in pressure and cut-out pressure is known as the **pressure differential**. This difference depends on the operating pressure of the system. It is recommended the spread be 20psi for system with pressures less than 80psi. This is increased to 30psi when pressures are over 80 psi and range up to 120psi. At pressures above 120psi it may be advantageous to have the spread greater than 30psi. It is important to check that the cut-out pressure is below the maximum pressure rating of the tank and the higher static pressure can be accommodated by the pipe rating and other pipeline appurtenances.



- vi. Friction Loss (FL):
    - The total calculated friction loss of the pipeline.
  - vii. Head Losses (HL):
    - Total friction losses through the system
      - $PL+FL$
  - viii. Min ON Elevation:
    - Used only for pressure tank systems.
    - The elevation corresponding to the ON switch setting of the pressure tank. Also refers to the elevation corresponding to the TDH calculated to operate the system.
      - $CP \text{ Elevation} + CH + HL$
  - ix. OFF Elevation:
    - Used only for pressure tank systems.
    - The elevation corresponding to the OFF switch setting of the pressure tank based on the recommended pressure differential.
      - $ON \text{ Elevation} + PR$
  - x. Total Dynamic Head (TDH):
    - The minimum TDH requirement to be used in selection of a pump.
    - For timer/float systems this is the calculated TDH from the pipeline tabs.
    - For pressure tank systems this is the TDH based on the assumed “average” operating conditions of the pressure tank.
      - $OFF \text{ Elevation} - PR/2 - WS$
  - xi. Design pump flow rate:
    - The Design Water Delivery Flow Rate (Q) as set on the ENG-39 tab.
- c) Enter the pump efficiency
- i. Default value is 65%
    - 65 is to be used unless the actual value is known
- d) Review the estimated pump motor size and the minimum pump requirements
- i. A message in red may appear when the flow requirements of the pump are greater than the flow rate of the pipeline. This occurs when an additional demand is placed on the system; i.e. domestic household use, irrigation, or other existing infrastructure.
    - The message notifies the user that additional flow is needed by the pump.
- e) Enter Comments for any additional pumping design requirements.

### 6.3 – Pressure Tank Sizing

Only a small percentage of a tank’s volume is available for useable water storage or **drawdown**. The majority of the tank volume is air. A tank’s efficiency refers to the portion of the total tank volume that is available for drawdown. Drawdown of the tank is equal to the water volume that is stored between the cut-in ON and cut-out OFF switch settings.

Common pressure tanks are rated for maximum operating pressures between 75psi and 150psi. This should be taken into consideration when determining the upper cut-out OFF switch setting. There are tanks available for up to 250psi but they are very expensive and the high pressures can be dangerous to work around. It is recommended that for systems with operating pressures above 150psi, some other type of pump control be used; i.e. timer/float or manually operated.

It is common to have pressure tanks come pre-charged with a set air pressure; normally 30psi. The amount of pre-charged air needs to be checked and adjusted to an amount that is 2-3psi below the cut-in ON setting to insure a complete drawdown of the tank. It is important to drain the tank completely before checking and setting the pressure in the tank. If you do not, the pressure will not be set correctly. Most pressure tanks are equipped with a Schrader valve (typical valves on most tires) and the air pressure can be easily adjusted.

Operating a pressure tank higher than its rated pressure is very dangerous. A tank used beyond its rating could explode and cause death or serious injury to anyone near the tank. For this reason, **a pressure tank should never be used beyond its rated pressure.** Tanks not designed for water use; i.e. used propane tanks, may tend to corrode and weaken as water is stored in them. **Pressure tanks not manufactured for water containment are not allowed for use.**

The Pressure tab of the workbook is only available when a pumped system is designed and is utilizing a pressure tank. The option to utilize a pressure tank is made on the Pump tab; see **Section 6.1 a)**. The Pressure tab is hidden when the pressure tank option is selected as “No”.

a) Calculating Drawdown

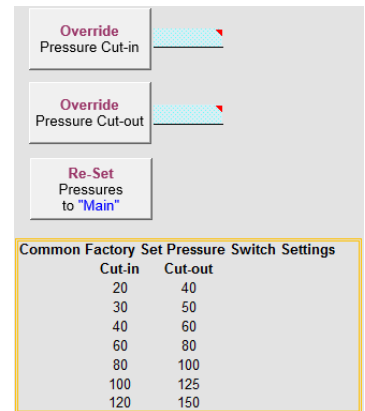
- i. Review the Pump Delivery Rate
  - The Design Pump Flow Rate ( $Q_{\text{pump}}$ ) as set on the ENG-39 worksheet.
- ii. Enter the Desired Minimum Pump Running Time (Cycle Time)
  - Default value is an industry recommended 1.5 minutes.
  - Use default value unless specific value is known from the pressure tank manufacturer.
- iii. Review the calculated minimum drawdown volume (water storage volume of the tank)
  - Pump Delivery Rate \* Pump Run Time

USDA United States Department of Agriculture		ND Stockwater Design Version: 4.2 North Dakota	
DIAPHRAGM PRESSURE TANK SIZING			
Producer:	Farmer Bob	Field Office:	Hettinger
Designed by:		Date:	
Checked by:		Date:	
<b>CALCULATING DRAWDOWN</b>			
1. Pump Delivery Rate	5.0	GPM	
2. Desired Minimum Pump Running Time (Cycle Time)	15	Minutes	
3. Multiply Line 1 by Line 2.	This is the minimum drawdown or available water volume required.		
	75	Gallons	
<b>CALCULATING TANK SIZE</b>			
4. Minimum System Pressure (Cut-in)	61	PSI	Check On Pressure
5. Maximum System Pressure (Cut-out)	91	PSI	Check Off Pressure
6. Calculated Factor	0.283	Factor	
7. Divide Line 3 by Line 6 to Determine the Minimum Volume Required.	26	Gallons	with a minimum pressure rating of 75 psi
Comments:			

b) Calculating Tank Size

- i. Minimum System Pressure (Cut-in)
  - Value calculated based on the system TDH requirement.
    - (Hydraulic Grade Line Elevation at Source – Pipe Centerline Elevation at Source) / 2.31ft/psi
- ii. Maximum System Pressure (Cut-out)
  - Value calculated based on the pressure differential between the cut-in and cut-out switch settings.
    - Cut-in Pressure + Pressure Differential
- iii. Calculated Factor
  - Commonly referred to as tank efficiency or the percentage of tank volume available for water storage.
  - Value calculated from the cut-in and cut-out pressure switch settings
    - $1 - ((\text{Cut-in Pressure} + 14.7) / (\text{Cut-out Pressure} + 14.7))$
- iv. Minimum Tank Volume and Pressure Rating
  - The total volume of the pressure tank is calculated by dividing the tank’s water volume by the tank efficiency.
  - The minimum working pressure of the pressure tank is set based on the maximum system operating pressure.
    - All pressure tanks are labeled showing the Max Working Pressure the tank is rated for.

- c) The pressure switch settings can be overridden to match common factory set pressure switch settings. A table is available in the Pressure tab with a list of common factory switch settings.
  - i. Enter the new Cut-in pressure
    - Click the **Override Pressure Cut-in** button
      - Line 4 of the Pressure Tank Sizing sheet is updated with the new pressure setting
  - ii. Enter the new Cut-out pressure
    - Click the **Override Pressure Cut-out** button
      - Line 5 of the Pressure Tank Sizing sheet is updated with the new pressure setting
  - iii. Click the **Re-Set Pressures to “Main”** button to reset back to the calculated values.



- d) Check On and Off Pressures
  - i. When the pressure switch settings are overridden, the pipeline hydraulics need to be recalculated.
    - Click on the **Check On Pressure** button
      - The Main (Final TDH) tab is activated and is a copy of the Main tab.
      - The source static pressure is set to the new Cut-in pressure value and the pipeline hydraulics are recalculated.
      - Review the system Working Pressure to ensure that there is an acceptable positive clearance head
    - Click on the **Check Off Pressure** button
      - The Main (Final TDH) tab is activated and is a copy of the Main tab.
      - The source static pressure is set to the new Cut-out pressure value and the pipeline hydraulics are recalculated.
      - Review the system Working Pressure to ensure that there are still acceptable system static pressures.
- e) Enter Comments for any additional pressure tank design requirements.



#### 6.4 – System and Pump Curves (System Checkout)

The water supply of any system should be able to deliver the design flow rate at the maximum pipeline operating pressure. The manner in which a system operates depends not only of the performance characteristics of the source (pump, storage tank, rural water, spring, etc) but also on the characteristics of the system that it will operate in. The performance of the source and the system that it operates in can be graphically displayed as a curve by plotting the amount of pressure (head) supplied or required against a corresponding flow that is produced.

One type of source characteristic curve is the **pump curve**. Pump curves are used by pump manufactures to provide a graphical representation of a pump’s performance. The curves are a relationship between flow and the hydraulic losses in the system. As the head requirements of the system increase (TDH), the volume produced by the pump decreases. The capacity of all pumps will continue to decrease until reaching a **shut-off head** where the volume produced becomes “0”.

Similarly, the relationship between flow and total head loss in a pipeline system can also be represented graphically and is known as the **system curve**. Since head loss is a function of flow, size and length of pipe, and minor losses, each pipeline system has its own characteristic system curve. A range of flow rates are used to calculate a corresponding TDH that is required to produce that flow. The system curve is completely independent of the pump characteristics.

When plotted together, the intersection between the system and source curve is called the **Operating Point**. For pump curves, the desired location of the operating point is within a noted recommended operating range of the pump curve; commonly referred to as the best efficiency range. If the operating point falls outside this best operating range, it will still pump the volume as indicated by the curve, but the pump will be less energy efficient.

The Curve tab of the workbook provides the ability

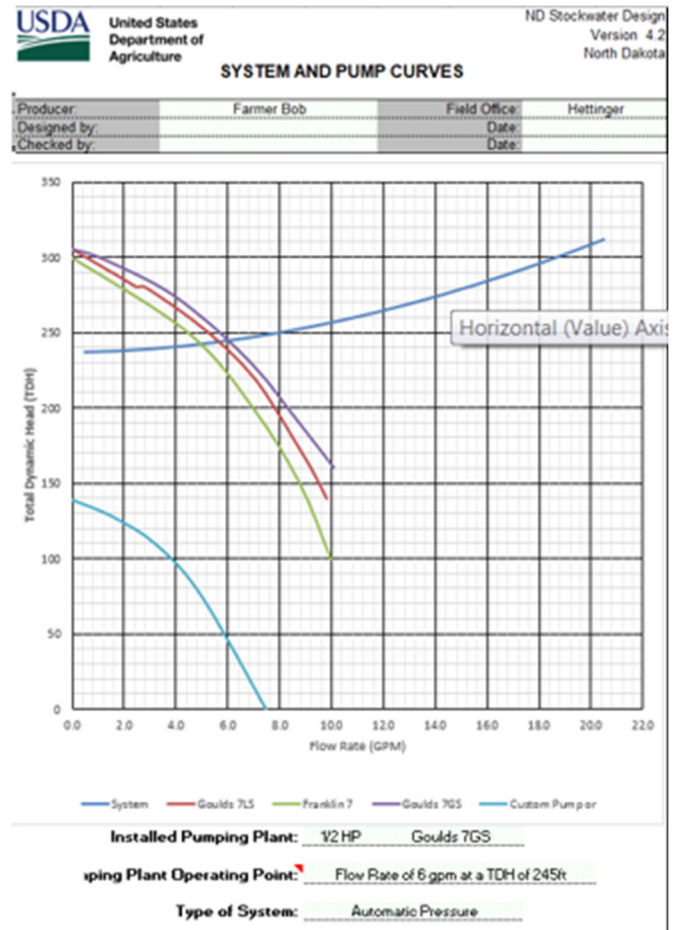
to plot both the system curve and pump curve and determine the systems operating point. Several models and sizes of pump along with their performance characteristics are preloaded into the workbook and available for selection. There is also the ability to model the performance characteristic of existing or other types of water sources. A range of pressure readings and corresponding flow rates are needed from the water source to create a performance curve that can be plotted against the system curve.

- a) Review the calculated system curve data.
- b) Select the installed pump or pump(s) to be analyzed from the drop-down list. Skip to Section c) if pump is not shown in list.
- c) Select the motor size of the installed pump or pump(s) to be analyzed from the drop-down list.
- d) Skip to Step d) if selections were made in Steps a) and b). Manually enter the performance data from the installed pump's data sheet in the custom section of the table.
- e) Select the appropriate radio button of the pump or custom water source that is to be used.
- f) Review the System and Pump Curves data sheet to determine if the installed pump or the pump being analyzed operates the system at the designed operating conditions.
  - i. The system curve and the curves of all entered pump options are plotted.
  - ii. Installed Pumping Plant:
    - Information for the selected pump or custom water source used.
  - iii. Pumping Plant Operating Point:
    - The flow rate and TDH of the pump curve and the system curve intersection.
  - iv. Type of System:
    - Automatic Pressure
      - Systems with a pressure tank
    - Time, Float, or Manual
      - Non-pressure type systems

Please Select Desired Pump ----->		<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>				
		Goulds 7LS	Franklin 7	Goulds 7GS	Custom Pump or Existing Water Source				
4 GPM		1/2 HP	1/2 HP	1/2 HP	Custom Source Info				
System	Pump Info #1	Pump Info #2	Pump Info #3	Custom Source Info					
GPM	TDH	GPM	TDH	GPM	TDH				
0.5	237	9.8	140	10.0	100	10.1	160	0.0	139
1.8	237	9.2	160	8.8	150	9.2	180	1.5	128
3.0	239	8.5	180	7.0	200	8.3	200	3.3	109
4.3	241	7.8	200	4.5	250	7.4	220	5.0	75
5.5	243	7.0	220	0.0	300	6.3	240	7.5	0
6.8	246	5.9	240	0.0	300	5.0	260		
8.0	250	4.5	260	0.0	300	3.4	280		
9.3	254	2.8	280	0.0	300	1.0	300		
10.5	258	2.5	280	0.0	300	0.0	305		
11.8	263	2.0	285	0.0	300	0.0	305		
13.0	269	1.5	290	0.0	300	0.0	305		
14.3	275	1.0	295	0.0	300	0.0	305		
15.5	281	0.5	300	0.0	300	0.0	305		
16.8	288	0.0	305	0.0	300	0.0	305		
18.0	295	0.0	305	0.0	300	0.0	305		
19.3	303	0.0	305	0.0	300	0.0	305		
20.5	311	0.0	305	0.0	300	0.0	305		

Intersection	Intersection	Intersection	Intersection
Flow: 5.7 gpm	Flow: 4.9 gpm	Flow: 6.0 gpm	Flow: 0.0 gpm
TDH: 243 ft	TDH: 242 ft	TDH: 244 ft	TDH: 0 ft





## Section 7 – Design of a Solar System


**This section will be completed after completion of Section 1 to Section 5.**

### 7.1 – Determining Design Solar Insolation

Design values for solar insolation can be determined from a network of weather stations across North Dakota that are part of the North Dakota Agricultural Weather Network (NDAWN). Based on parameters selected, corresponding solar insolation values are downloaded from the NDAWN website into the design tool.

A statewide averaged insolation value can be chosen or a specific value for a selected NDAWN station can be used. A user inputted value can also be directly entered. The following steps are a guide for the Solar Resource tab of the workbook.

- a) Choose either **Yes** or **No** from the dropdown menu for “**Do you want to use the average state value for design?**”
  - i. **Yes** uses the average monthly value from October for the Period of Record of all NDAWN stations. As of July 2017, this value is 2.42. Skip to **Step (h)** if state average is used.
  - ii. **No** requires a selection of a specific NDAWN station. Continue to **Step (b)** if selecting a NDAWN station.
- b) Select a **NDAWN Station** from the dropdown list that is nearest to the project site.
- c) Select the **Data Frequency** from the dropdown list for the frequency of the data downloaded from the NDAWN station.
  - i. **daily** sets to download the daily data for the selected **NDAWN Station** for the **Length of Data Record**. Proceed to **Step (d.i)**.
  - ii. **monthly** sets to download the monthly data for the selected **NDAWN Station** for the **Length of Data Record**. Proceed to **Step (d.ii)**.



**United States  
Department of  
Agriculture**

ND Stockwater Design  
Version: 4.2  
North Dakota

**SOLAR INSOLATION CALCULATOR / NDAWN INSOLATION DATA DOWNLOAD**

Producer: Farmer Bob

Designed by:

Checked by:

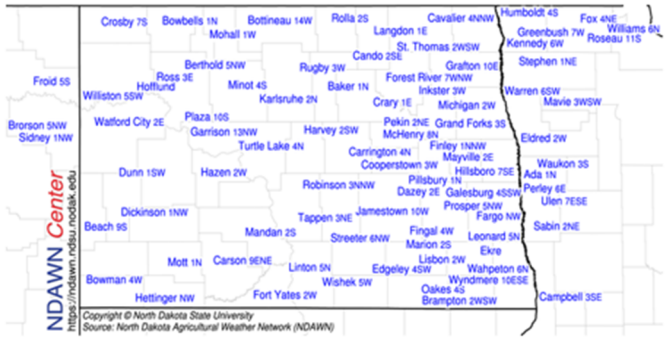
Field Office: Hottinger

Date:

Date:

**NDAWN Website for Data Download:**

[https://ndawn.ndsu.nodak.edu/table.csv?station=29&variable=mdsr&year=2024&type=monthly&quick\\_pick=por](https://ndawn.ndsu.nodak.edu/table.csv?station=29&variable=mdsr&year=2024&type=monthly&quick_pick=por)



Copyright © North Dakota State University  
Source: North Dakota Agricultural Weather Network (NDAWN)

**\* Please use the options below to determine the local solar insolation value for the project.**

NDAWN Station: Hottinger Get NDAWN Data

Data Frequency: monthly

Length of Data Record: Period of Record

Month to Analyze: September    # of months: 34

Data Statistics: Average

**\* The entered data is valid for the selected NDAWN Station.**

**Total Daily Insolation** 4.42 hours/day @ 1-5pm (100%+)

Water Use Given the Location's Solar Insolation Value ( $Q_{ins}$ ): **Daily Water Use**


$f$  (Insolation \* 60) = 20.7 **gpm**

**\* Production of installed pump and solar array combination to be at least  $Q_{ins}$ .**


Comments:

Values of a Typical Growing Season for the Period of Record of the Selected NDAWN Station		
Month	Temp. Value	Hum. Value
March	3.34	23.27
April	4.36	18.41
May	5.83	15.72
June	6.57	13.35
July	6.78	13.52
August	5.84	15.70
September	4.46	20.57
October	2.88	31.88

**Note:** **monthly** is the most common frequency used in design. **daily** can be used when a more detailed analysis of the site is desired.

- d) Select the **Length of Data Record** from the dropdown list for the time frame of data downloaded from the NDAWN station.
- i. A data frequency of **daily** gives the following options:
    - **Previous # of Days**
      - Select the **Previous # of Days** from the dropdown menu: 7, 14, 30, 60, 90, 100
      - Sets to download the daily data for only the past # of days chosen for the selected **NDAWN Station**.
  - ii. A data frequency of **monthly** gives the following options:
    - **Period of Record**
      - Sets to download all months of the selected **NDAWN Station**'s period of record up to the current previous month.
    - **Last Two Years**
      - Sets to download all months from the previous 2 years starting with the current previous month for the selected **NDAWN Station**.
    - **Beginning Month and Year**
      - Select the **Beginning Month #** from the dropdown menu.
      - Enter the corresponding year (i.e. 2007) for the selected **Beginning Month**.
- e) Click the  button to download the data table from the NDAWN website for the parameters set in **Step (d)**.
- i. Internet access is required for the download to execute.
  - ii. The URL for the website where the data table is downloaded from is located at the top of the Solar Resource tab under the heading **NDAWN Website for Data Download**.
  - iii. The downloaded data is transferred into the workbook and can be viewed in the Solar Data tab.
  - iv. A message in red appears when the **NDAWN Station** is changed and is different than the data currently loaded in the Solar Data tab.
 

**\* NDAWN Station has changed. Please click on Get NDAWN Data button to download the Station data.**



The screenshot shows a form with the following fields:
 
    - NDAWN Location:** Ada
    - Data Frequency:** monthly
    - Length of Data Record:** Period of Record
    - Month to Analyze:** October
    - # of months:** 10
  - v. A message in red appears when inputs for **Data Frequency** and **Length of Data Record** are changed.
 

**\* Data inputs have changed. Please click on the Get NDAWN Data button to update values.**
- f) Select the **Month to Analyze** from the dropdown menu.
- i. Either a **# of months** or **# of days**, depending on the **Data Frequency** selected, will be calculated from the data downloaded and located in the Solar Data tab. The number is representative of the number of solar insolation values for the month being analyzed.
 

Example: There are 10 October solar insolation values for the Period of Record from the Ada NDAWN station.
- g) Select a **Data Statics** from the dropdown menu to determine the design solar insolation value.
- i. **Average** – Returns an average solar insolation value from all values of the downloaded data set for the selected **Month to Analyze** and displays it as the **Total Daily Insolation** value.
  - ii. **Minimum** – Returns the minimum solar insolation value from all values of the downloaded data set for the selected **Month to Analyze** and displays it as the **Total Daily Insolation** value.
  - iii. **Percentile** – Returns the n<sup>th</sup> percentile of the solar insolation value from all values of the downloaded data set for the selected **Month to Analyze** and displays it as the **Total Daily Insolation** value.
    - Enter a percentage as a whole number.

Example:

- 0% returns the minimum value
- 10% returns a value that is less than 90% of all other values.
- 90% returns a value that is greater than all but 10% of all values.
- 100% returns the maximum value.

- h) Review the resulting **Total Daily Insolation** value.
- i. This is the design insolation value to use for the design and is representative of the number of peak sun hours at 1-Sun (1kW/m<sup>2</sup>) the site receives per day based on the **Month to Analyze** and set **Data Statistics**.
  - ii. The **Total Daily Insolation** value can be overridden as a user input.  
 Example: When analyzing a design from a solar dealer, installer or other design software, the solar insolation value used can be manually entered to evaluate the resulting flow rate and system production.
    - A message in purple appears when the Total Daily Insolation value is overridden.  
 \* **Insolation value does not match the NDAWN value for the selected site. A user defined value is being used. NDAWN value for the selected site is: \_\_\_.**
- i) Review the calculated **Flow Rate Required to Achieve Daily Water Use Given the Location’s Solar Insolation Value (Q<sub>Inso</sub>)**.
- i. The resulting flow rate, in gallons per minute (GPM), that the pump and solar array combination has to meet in order to supply the daily water requirements of the livestock determined on the ND-ENG-39 tab.
  - ii. **Q<sub>Inso</sub>** is one of the characteristics to be used in the evaluation and selection of a pump/controller.
- j) A table is provided in the lower right hand corner of the data sheet that lists the average solar insolation values and resulting required flow rate for the months of March – October for the selected **NDAWN Station**.
- i. The table is only applicable for a **Data Frequency of monthly** and a **Length of Data Record set to Period of Record**.
- k) A comments section is available at the bottom of the data sheet for documentation of design decisions and justifications for values used.

Month	Inso Value	Flow Rate
March	3.68	4.53
April	4.66	3.58
May	5.26	3.17
June	5.79	2.88
July	6.21	2.68
August	5.24	3.18
September	3.93	4.24
October	2.30	7.23

## 7.2 – Calculating the Required Total Dynamic Head (TDH) for the System

The total dynamic head (TDH) of a solar-power watering system can be calculated for both a submersible pump installation such as a well or for a surface pump installation such as pumping out of a pond or stream. The location of the watering facility that stores the outputted water also is a factor in determining the required TDH of the system. The following steps are a guide for the TDH tab of the workbook.

- a) Review the **Design Pump Flow Rate**
  - i. This value is the calculated  $Q_{Inso}$  from the Solar Resource tab. See **Section 7.1** for the process of determining this value; if a change is necessary.
- b) Review the **Water Surface Elev. When Pumping (WS)**
  - i. WS is the water surface elevation of the water source when pumping and is populated from the entry on the ENG-39 tab. See **Section 3.2, Step (i)**.
- c) **Is water being pumped out of a well?** Select **Yes** or **No** from the dropdown menu.
  - i. **Yes** – Enter the **Ground elev. at well (W\_Elev)**; skip to **Step (g)**.
  - ii. **No** – Enter the **Ground elev. at pump (P\_Elev)**; continue to **Step (d)**.
    - For use with surface pumps that are set to pump out of a pond or stream.
- d) Enter a description of the **Pump Location** if using a surface pump.
 

Example: “an existing dugout pond”
- e) Review the calculated **Suction lift (SL)** of the surface pump.
  - i. The suction lift is the elevation difference from the ground elevation at the surface pump to the water surface elevation of the pond or stream when pumping.
  - ii. If the suction lift exceeds 25ft, a warning message appears in red.
 

**\*Warning: Suction Lift >25ft. Cavitation is likely. System layout needs to be modified.**
- f) Enter the **Length of pump suction hose (LSH)** if using a surface pump.
  - i. The hose length is from the suction inlet of the surface pump to the beginning of the intake screen in the pond or stream.
- g) **Is the storage located near the well/pump outlet?** Select **Yes** or **No** from the dropdown menu.
  - i. **Yes** – Enter the **Height above ground to inlet of storage (HT)**; skip to **Step (j)**.
  - ii. **No** – Enter the **Height above ground to inlet of storage (HT)**; continue to **Step (h)**.
- h) Enter the **Distance from well to storage (DS)** for a storage tank located remotely.
- i) Enter the **Ground elev. at storage (S\_Elev)** for a storage tank located remotely.
- j) Review the calculated **Total Vertical Lift (VL)**.
  - i. For a storage located near a well;  $VL = W\_Elev - WS + HT$
  - ii. For water storage located remotely from a well;  $VL = S\_Elev - WS + HT$
  - iii. For a storage located near a surface pump;  $VL = SL + HT$
  - iv. For water storage located remotely from a surface pump;  $VL = S\_Elev - P\_Elev + SL + HT$

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**TOTAL DYNAMIC HEAD AND HYDRAULIC WORKLOAD FOR SOLAR PUMP**

Producer: Farmer Bob Field Office: Hettinger  
 Designed by: Date:  
 Checked by: Date:

Design Pump Flow Rate: 7.2 gpm Is water being pumped out of a well? Yes  
 Water surface elev. when pumping (WS) = 740 MSL  
 Ground elev. at well (W\_Elev): 798 MSL

Is the storage located near the well? Yes  
 Height above ground to inlet of storage (HT) = 0 ft  
 Total Vertical Lift (VL): W\_Elev - WS + HT = 58 ft Total Length of Pipeline (LP), ft = 10

**Pipe Friction Loss**

Column Pipe Type: 1120 - PVC SCH40 Pipeline Type: 4710 - 508 11 - OOD Losses in Pipe Fittings (PFL):  
 Column Pipe Size: 1 1/4 Pipeline Size: 1 1/2  
 Column Pipe Losses (CPL): 0.46 ft Pipeline Losses (PL): 0.05 ft 0.61 ft

Total Friction Loss (TFL): CPL + PL + PFL = 1.12 ft  
**Total Dynamic Head**  
 TDH: VL + TFL = 60 ft

**System Layout Summary:** A solar pump to be installed in a well. The solar system pumps to a storage tank located near the well

Hydraulic Workload (HW) 70 m³  
 \*Hydraulic Workload: The amount of work required to supply a water demand against a total pumping head (or TDH)

HW	Comment	Check
< 1,500	Power supplied by a properly sized solar system is adequate	X
1,500-2,000	Use of solar system may be limited by power required	
> 2,000	More power required than can be reasonably supplied by solar	

Comments:

k) Review the calculated **Total Length of Pipeline (LP)**.

**Note:** The pipeline length is only for pipe between the water source and the water storage at the outlet of the pump. Pipeline extending from the outlet of the water storage is to be designed separately.

- i. For a storage located near a well;  $LP = HT + 10'$  of miscellaneous plumbing between well and storage.
- ii. For water storage located remotely from a well;  $LP = VL + DS$
- iii. For a storage located near a surface pump;  $LP = LSH$
- iv. For water storage located remotely from a surface pump;  $LP = LSH + DS$

**Pipe Friction Loss:**

l) Select the **Column/Suction Pipe Type** from the dropdown menu.

- i. For a well; column pipe is the pipe that connects to the pump and is placed down into the well.
  - Typical column pipe is 1120 – PVC SCH 40
- ii. For a surface pump; suction pipe is the pipe that runs from the pump down into the pond or stream.
  - Suction pipe should be rated for above ground use.

m) Select the **Column/Suction Pipe Size** from the dropdown menu.

- i. For column pipe; the size depends on the NPT outlet of the pump and typically ranges from 1” to 2”.
- ii. For suction pipe; the size depends on the size of the suction inlet of the pump.

n) Review the calculated **Column/Suction Pipe Losses (CPL/SPL)**.

- i. The friction loss through the column/suction pipe is automatically calculated by solving for the head loss from the Hazen-Williams equation.

o) Select the **Pipeline Type** from the dropdown menu.

p) Select the **Pipeline Size** from the dropdown menu.

q) Review the calculated **Pipeline Losses (PL)**.

**Note:** The pipeline length is only for pipe between the water source and the water storage at the outlet of the pump. Pipeline extending from the outlet of the water storage is to be designed separately.

- i. The friction loss through the pipeline is automatically calculated by solving for the head loss from the Hazen-Williams equation.

r) Review the calculated **Losses in Pipe Fittings (PFL)**.

- i. The friction loss is for the piping at the well or surface pump. Default fittings and values are included in a chart located to the right of the data sheet. The fitting’s size is assumed to be the same as for the **Pipeline Size**. At the very least, the fitting’s material should be changed; as needed.
- ii. The friction loss through the fittings is automatically calculated by solving for the head loss from the Hazen-Williams equation.

s) Review the **Total Friction Loss (TFL)**.

- i. The total friction loss through all piping between the pump and the water storage.
- ii. For a pump within a well;  $TFL = CPL + PL + PFL$
- iii. For a surface pump;  $TFL = SPL + PL + PFL$

**Total Dynamic Head:**

t) Review the calculated **Total Dynamic Head (TDH)**.

- i. The total head the pump has to work against to deliver the required flow rate  $Q_{Inso}$ .
- ii.  $TDH = VL + TFL$
- iii. **TDH** is one of the characteristics to be used in the evaluation and selection of a pump/controller.

<b>Select Fittings for Plumbing Within Well Pit / Pump House</b>			
Type	Material	Quantity	Head Loss (ft)
Elbow-90 deg	Steel	4	0.29
Standard Tee	Steel	1	0.05
Gate Valve	Steel	1	0.02
Check Valve	Steel	1	0.24
<b>Pipe Fitting Loss (ft):</b>			<b>0.61</b>

### 7.3 – System Layout Summary and Hydraulic Evaluation

- a) Review the **System Layout Summary** as compiled by the design choices made in **Section 7.2**.
- b) Review the calculated **Hydraulic Workload (HW)** of the system.
  - i. Hydraulic workload is the amount of work required of a watering system to supply water;  $Q_{Inso}$ , against a total pumping head; TDH.
- c) Review the hydraulic workload table to determine if solar-power is a viable option for the system. The row in which the calculated HW falls is highlighted green, yellow, or red.
  - i. If HW is < 1,500 then the power supplied by a properly sized solar system is adequate.
    - Row is highlighted **GREEN**
  - ii. If HW is 1,500 – 2,000 then the power required by the system may be limited by the use of solar-power.
    - Row is highlighted **YELLOW**
  - iii. If HW is > 2,000 then more power is required by the system then can be reasonably supplied by solar.
    - Row is highlighted **RED**
- d) A comments section is available at the bottom of the data sheet for documentation of design decisions and justifications for values used.

### 7.4 – Solar Pump Evaluation

Solar insolation, daily livestock water demand, and total dynamic head are the three main factors in determining the right solar pump and panel array combination. The orientation and tilt angle of the solar array is also key in assuring that the system performs efficiently. The following steps are a guide for the Pump and Array tab of the workbook.

- a) Review the **Solar Insolation Value**
  - i. This is the **Total Daily Insolation** value determined on the Solar Resource tab. See **Section 7.1** for the process of determining this value; if a change is necessary.
- b) Review the **Daily Water Demand (WU)**
  - i. WU is the total daily water use of the livestock that is documented on the ENG-39 tab. See **Section 3.2**.
- c) Review the **Pump Flow from Solar Insolation ( $Q_{Inso}$ )**
  - i.  $Q_{Inso}$  is the calculated flow rate required to meet the daily demand based on the design solar insolation value. See **Section 7.1** for the process of determining this value; if a change is necessary.
- d) Review the **Pump Head Requirement (TDH)**
  - i. TDH is the total dynamic head calculated in the TDH tab. See **Section 7.2** for the process of calculating this value; if a change is necessary.

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**SOLAR PUMP AND ARRAY EVALUATION**

Producer: Farmer Bob Field Office: Hettinger  
 Designed by: Date:  
 Checked by: Date:

**Location and Pump Requirement Summary**

Solar Insolation Value: 2.42 kWh/d Daily Water Demand (WU): 1000 GPD  
 Pump Flow Rate from Solar Insolation ( $Q_{Inso}$ ): 6.9 gpm Pump Head Requirement (TDH): 62 ft

**Pump Data**

Pump Brand to Evaluate: Grundfos Required Pump Input Power ( $P_{in}$ ): 172 W  
 Grundfos Model #: 11-SGF-2 0.17 kW  
 Pump Efficiency ( $P_{eff}$ ): 47% Calculated pump efficiency =  $0.1885 \cdot TDH \cdot Q_{Inso} / P_{in}$   
 Pump Operating Voltage ( $P_{V_{ops}}$ ): 120 Volts Grundfos recommends at least 120V for best performance

**Solar Panel Data**

Brand of Solar Panel: BP Solar Max Power ( $P_{max}$ ): 175 Watts  
 Solar Panel Model #: BP-4175B Max Power Voltage (Vmpp): 35.4 Volts  
 Example: BP Solar - BP4175B Max Power Current (Impp): 4.9 Amps  
 Solar Panel De-Rating Value (DRV): 85%

Solar Panels in Series ( $SP_{series}$ ):  $P_{max} / V_{mpp} = 4$  # of Series in Parallel ( $SP_{parallel}$ ):  $P_{in} / (SP_{series} \cdot V_{mpp} \cdot DRV) = 1$   
 Total # Panels in Array ( $SP_{total}$ ):  $SP_{series} \cdot SP_{parallel} = 4$

**Solar Array Orientation and System Production**

Solar Panel Mount Tilt Angle: Grazing Season 37.5° tilt angle,  $\Sigma$  with solar array facing due south  
 \* Grazing Season defined as March - October

Output of Solar Configuration ( $Q_{Inso}$ ):  $(V_{mpp} \cdot I_{mpp} \cdot SP_{total} \cdot Insolation \cdot 60 \cdot DRV \cdot P_{eff}) / (0.1885 \cdot TDH)$   
 $Q_{Inso}$ : 3443.3 GPD  
 Actual Flow Rate for Solar Configuration: 23.7 gpm

**Solar System Summary:** The solar system consists of a Grundfos\_11\_SGF\_2 pump and compatible controller powered by a total of 4 BP Solar BP-4175B solar panels. The solar array is to be wired in parallel with 1 set of 4 panels in series and installed on a mount set at a fixed tilt angle of 37.5°.

Comments:

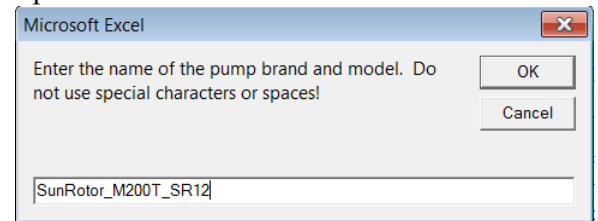
#### Pump Data:

- e) Select the **Pump Brand to Evaluate** from the dropdown menu.
  - i. **Grundfos, Lorentz, Franklin, SunPumps, RPS**
    - A preloaded list of these solar pumps are available for evaluation; continue to **Step (f)**.
  - ii. **Other**
    - Any brand of solar pump can be evaluated by entering the pump's specific characteristics; skip to **Step (g)** for the process of entering a custom pump.
- f) Select the pump **Model #** from the dropdown menu.

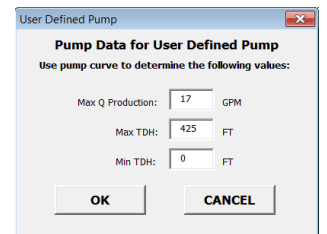
- i. If both the required  $Q_{Inso}$  and **TDH** fall within the performance curve of the pump then the resulting **Required Pump Input Power ( $P_{in}$ )**, **Pump Efficiency ( $P_{Eff}$ )**, and **Pump Operating Voltage ( $P_{volts}$ )** are displayed.
  - The Pump Tables tab contains the pump data tables for each of the preloaded pumps and can be reviewed as necessary.
- ii. If the required **TDH** falls within the performance curve of the pump but the required  $Q_{Inso}$  is greater than what the pump can produce; a message in blue appears noting the max flow rate the pump is able to produce against the required **TDH**.
  - **\* The max production of the selected pump for the required TDH is \_\_ GPM.**
- iii. If the required  $Q_{Inso}$  falls within the performance curve but the **TDH** is less than the minimum TDH of the pump performance curve; a message in red appears noting the minimum TDH required of the pump.
  - **\* The min TDH of the selected pump for  $Q_{Inso}$  is \_\_ft. Please try a different pump or model.**
- iv. If the required  $Q_{Inso}$  falls within the performance curve but the **TDH** is more than the maximum TDH of the pump performance curve; a message in red appears noting the maximum TDH of the pump.
  - **\* The max TDH of the selected pump for  $Q_{Inso}$  is \_\_ft. Please try a different pump or model.**
- v. If both the required  $Q_{Inso}$  and **TDH** fall are outside the performance curve of the pump; a message in red appears noting that both the flow and head are outside the operating conditions of the pump. A message highlighted in red will also display showing the pump limits for flow and TDH.
  - **\* Both Q and TDH are outside the operating range of the pump model. Please try a different pump or model.**
  - **Selected pump has a min/max operating TDH of \_\_\_' and min/max Q of \_\_\_ gpm.**

**g) Select Other** from the **Model #** dropdown menu if the desired pump is not available from those listed.

- i. Enter the name of the pump brand and model for the pump to be analyzed and click **OK**.
  - The entry cannot contain any spaces or special characters such as / \ . - , ect.
  - Example: For a SunRotor SR-12 pump with a M200T controller, the entry would be SunRotor\_M200T\_SR12



- ii. Using the pump's performance curve, enter the pump data for the user defined pump and click **OK**.
  - **Max Q Production** in GPM
  - **Max TDH** in FT
  - **Min TDH** in FT



- iii. Click **Yes** or **No** to the question of **“Does the pump curve have an axis for pump input power?”**
  - **Yes** – A box appears asking to use the pump curve with  $Q_{Inso}$  and **TDH** to determine the required pump input power. Click **OK**. Continue to **Step (g.iv)**
  - **No** – The required pump input power is manually calculated. Skip to **Step (g.v)**
- iv. Enter the required pump input power in Watts using the pump curve for the systems  $Q_{Inso}$  and **TDH** and click **OK**.
- v. Enter the pump voltage from the pump curve, if applicable, or enter the optimal Q operating voltage from the pump technical data sheet and click **OK**.

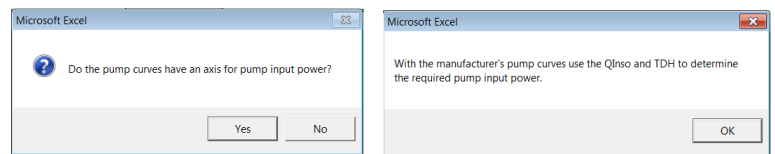
- h) Review the **Required Pump Input Power ( $P_{in}$ )** for the selected pump model.
  - i.  $P_{in}$  is determined from the pump performance curve of the selected pump model using the system's required  $Q_{inso}$  and TDH.
  - ii.  $P_{in}$  is the amount of power required by the pump and to be supplied by the solar array.
- i) Review the **Pump Efficiency ( $P_{Eff}$ )** calculated for the selected pump model.
  - i.  $P_{Eff} = 0.1885 * TDH * Q_{inso} / P_{in}$
- j) Review the **Pump Operating Voltage ( $P_{volts}$ )** for the selected pump model.
  - i. For Grundfos and Lorentz pumps, the optimum operating voltage of the pump model is used as the default. This value is found in the technical data documentation for the pump and preloaded into the workbook on the Pump Tables tab.
  - ii. For SunPumps pumps, the optimum operating voltage is part of the pump performance curve and is determined using the system's required  $Q_{inso}$  and TDH.

### 7.5 – Solar Panel Evaluation

- a) Enter the **Brand of Solar Panel**.
  - i. Example: BP Solar
- b) Enter the **Solar Panel Model #**.
  - i. Example: BP 4175B

**Use the technical data sheet or sticker label on the panel to determine the values for Steps (c-f):**

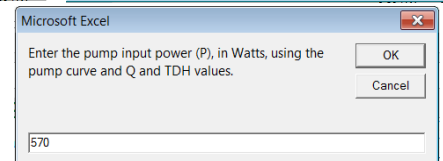
- c) Enter the **Max Power ( $P_{max}$ )** of the selected solar panel.
  - i.  $P_{max}$  is the rated maximum power supplied by the solar panel
- d) Enter the **Max Power Voltage ( $V_{mpp}$ )** of the selected solar panel.
  - i.  $V_{mpp}$  is the rated voltage supplied by the panel at rated max power.
- e) Enter the **Max Power Current ( $I_{mpp}$ )** of the selected solar panel.
  - i.  $I_{mpp}$  is the rated current supplied by the panel at rated max power.
- f) Enter the **Solar Panel De-Rating Value (DRV)** of the selected solar panel.
  - i. DRV is the percentage of max power that the panel can supply over the rated life of the panel.
  - ii. 80-85% is a common DRV for most solar panels used in solar-powered watering systems.
- g) Review the calculated # of **Solar Panels in Series ( $SP_{Series}$ )**.
  - i. The number of panels to be wired in series is calculated by dividing the optimum operating voltage required of the pump by the max power voltage supplied by the solar panel.
 
$$SP_{Series} = P_{volts} / V_{mpp}$$
  - ii. The value can be overridden with a user input if evaluating an existing system or to check if fewer solar panels can be used.
    - Voltages supplied by the solar array that are less than the optimum operating voltage of the pump can result in decreased production of the system.



- h) Review the calculated # of **Series in Parallel ( $SP_{II}$ )**.
  - i. The number of panel strings (string = panels wired in series) to be wired in parallel

$$SP_{II} = P_{in} / (SP_{Series} * V_{mpp} * I_{mpp} * DRV)$$

- ii. The value can be overridden with a user input if evaluating an existing system or to check if fewer solar panels can be used.

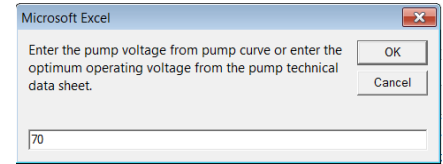


- i) Review the calculated **Total # of Panels in Array ( $SP_{Total}$ )**.
  - i. The total number of panels that make up the solar array is calculated by multiplying the number of panels wired in series by the number of panel strings wired in parallel.

$$SP_{Total} = SP_{Series} * SP_{II}$$



- j) Review the configuration of the solar array and selected pump/controller.
- i. Solar pumps and their associated controllers are rated for a maximum allowable input wattage, voltage, and current. A message in red will appear when an entered solar array configuration exceeds the limits of the pump/controller combination.



- **\* Warning: Solar array produces a wattage exceeding the rating of the pump system! Damage to the system may occur!**

- k) Select the **Solar Panel Mount Tilt Angle** from the dropdown menu.

- i. **Annual** – The determined optimal tilt angle of a fixed-axis mount for year round production.
    - The optimal tilt angle for the best production of the system year round is equal to the latitude of the local site.
  - ii. **Summer** – The determined optimal tilt angle of a fixed-axis mount for production in May-Aug.
    - The optimal tilt angle for the best production of the system during the summer is equal to the latitude of the local site –15°.
  - iii. **Grazing Season** – The determined optimal tilt angle of a fixed-axis mount for production during a typical grazing season from March-October.
    - The optimal tilt angle for the best production of the system during a typical grazing season.
  - iv. **Single-Axis Tracker** – A mount with a fixed vertical axis set at an angle of the local latitude and a horizontal axis that tracks the movement of the sun from east to west.
  - v. **Double-Axis Tracker** – A mount with both a vertical and horizontal axis that tracks the movement of the sun across the sky.
- l) Review the resulting **Solar Panel Mount Tilt Angle**.
- i. The tilt angle is determined based on the location of the selected NDAWN station used in determining the project site’s solar insolation value.

Historic Water Storage Budget Summary						
Year	Month	Average Insolation Value	Production of Solar Setup	Demand, Gallons	Storage, Gallons	Supplemental Water, Gallons
2014	3	3.16	54,006	31,000	3,000	0
2014	4	4.44	73,298	30,000	3,000	0
2014	5	5.02	85,698	31,000	3,000	0
2014	6	4.63	76,480	30,000	3,000	0
2014	7	6.30	107,599	31,000	3,000	0
2014	8	4.12	70,257	31,000	3,000	0
2014	9	3.98	65,768	30,000	3,000	0
2014	10	2.39	40,795	31,000	3,000	0
2014	11	1.41	23,292	30,000	3,000	3,708
2014	12	1.13	19,225	31,000	0	11,775
2015	1	1.50	25,569	31,000	0	5,411
2015	2	2.26	34,794	28,000	0	0
2015	3	3.73	63,703	31,000	3,000	0
2015	4	4.81	79,429	30,000	3,000	0
2015	5	5.46	93,210	31,000	3,000	0
2015	6	5.95	98,294	30,000	3,000	0
2015	7	6.47	110,424	31,000	3,000	0
2015	8	5.83	99,564	31,000	3,000	0
2015	9	4.60	75,942	30,000	3,000	0
2015	10	2.56	43,724	31,000	3,000	0
2015	11	1.66	27,414	30,000	3,000	0
2015	12	1.16	19,787	31,000	414	10,798
2016	1	1.47	25,042	31,000	0	5,958
2016	2	2.09	32,155	28,000	0	0
2016	3	3.62	61,711	31,000	3,000	0
2016	4	4.27	70,588	30,000	3,000	0
2016	5	6.13	104,582	31,000	3,000	0
2016	6	7.47	123,338	30,000	3,000	0
2016	7	6.29	107,317	31,000	3,000	0
2016	8	5.89	100,559	31,000	3,000	0
2016	9	3.58	59,092	30,000	3,000	0
2016	10	2.25	38,376	31,000	3,000	0
2016	11	1.68	27,668	30,000	3,000	0
2016	12	1.34	22,953	31,000	668	7,380
2017	1	1.73	29,444	31,000	0	1,556
2017	2	2.61	40,243	28,000	0	0
2017	3	3.52	60,043	31,000	3,000	0
2017	4	4.70	77,629	30,000	3,000	0
2017	5	6.54	111,575	31,000	3,000	0
2017	6	6.96	115,012	30,000	3,000	0

## 7.6 – System Evaluation and Summary

It is important to evaluate the actual production of the solar pump and solar array configuration to determine if the planned or installed system meets the watering requirements of the design.

- a) Review the calculated **Output of Solar Configuration (Q<sub>System</sub>)**.
- i. A production output is calculated for the pump and solar array combination evaluated in **Section 7.1 and 7.2**; respectively.
    - $Q_{System} = (V_{mpp} \times I_{mpp} \times SP_{Total} \times \text{Solar Insolation} \times 60 \times \text{DRV} \times P_{Eff}) / (0.1885 \times \text{TDH})$
    - A message in red appears when the pump and array configuration do not meet the daily water requirements of the system.
      - **\* Q<sub>System</sub> less than daily water use (WU). The pump and panel configuration do not meet the daily waster demand of \_\_\_ GPD.**

- b) Review the **Actual Flow Rate for Solar Configuration**.
  - i. The actual flow rate in GPM that the system produces based on the configuration of the pump and solar array.
    - The rate is calculated by dividing the output of the solar configuration by the system’s design solar insolation value; **Flow Rate = QSystem / (Solar Insolation x 60)**.
- c) Review the **Solar System Summary** as compiled by the design choices made in **Section 7.4 and 7.5**.
- d) A comments section is available at the bottom of the data sheet for documentation of design decisions and justifications for values used.

### 7.7 – Running a Water Budget

An effective way to determine if the storage provided is sufficient is through a water balance. A water balance will determine how much storage is still available during any period of time by keeping track of the production and demands into and out of the system. The water budget within the design workbook analyzes the monthly production and demands of the system and determines the months when the volume of the provide storage is exceed and supplemental water is needed. Additional statistical information is calculated as well. The following steps are a guide for the Water Budget tab of the workbook.

- a) Click the **Get Inso** to import the historical insolation values for the selected NDAWN Station on the Solar Resource tab; see **Section 4.1(b)**.

Historic Water Storage Budget Summary	
Storage Volume:	3,000 gallons
Budget Starting Volume:	0 gallons
Low Volume Check:	100 gallons
NDAWN Station:	Hazen

- i. A table is populated for each month of the NDAWN Station’s Length of Data Record selected on the Solar Resource tab; see **Section 7.1(d)**.
  - ii. Production of the system is calculated for each month using the month’s average solar insolation value as determined on the Solar Resource tab; see **Section 7.1(b-h)**.
  - iii. A monthly system demand is calculated for each month using the total daily water (**WU**) use of the livestock documented on the ENG-39 tab. See **Section 3.2(a-d)**.
- b) Enter the **Storage Volume** of the system.
  - i. The storage volume must meet the North Dakota minimum 3 days storage.
    - **Minimum Storage Volume = WU x 3**
- c) Enter the **Budget Starting Volume** of the storage tank.
  - i. It is recommended that the starting volume be 0; assuming that the storage will be empty initially.
- d) Enter a **Low Volume Check** for the storage tank, if desired.
  - i. If you would like to know how many times the storage tank gets lower than some point, enter that volume in gallons or enter 0 if you don't care.
- e) Review the data in the **Historic Water Storage Budget Summary** table.
  - i. The table shows the monthly historical production and demand of the system and calculates whether supplemental water is needed over what the storage tank is able to provide in a given month.
    - **Supplemental Water = Demand – Production – Remaining Storage of Previous Month**
  - ii. If the table shows no supplemental water needed during the months when the system is being used; i.e. March – October, then the provided storage volume is sufficient for the system.
  - iii. If supplemental water is shown to be needed during the system’s season of use then revisit the system design parameters to either increase the production of the system or decrease the demands on the system

f) Review the **Historic Water Storage Budget Statistics**.

- i. **Start Year – End Year**
- ii. **NDAWN Station  
Period of Record**
- iii. **Average Insolation**
- iv. **Min Insolation**
- v. **Max Insolation**
- vi. **Average Production**
- vii. **Median Production**
- viii. **Average Demand**
- ix. **Average Storage**
- x. **Median Storage**
- xi. **Storage was Dry**
- xii. **Storage < Low Volume Check**
- xiii. **Average Supplemental Water**
- xiv. **Median Supplemental Water**
- xv. **Total Supplemental Water**

Start Year =	1993	End Year =	2017		
NDAWN Station Period of Record =	287 months	23.9 years			
Average Insolation =	3.84 hr/day				
Min Insolation =	0.98 hr/day	December	2004		
Max Insolation =	7.47 hr/day	June	2016		
Average Production =	2146 gal/day	64,384 gal/month		772,605 gal/yr	
Median Production =	2206 gal/day	66,168 gal/month		794,019 gal/yr	
Average Demand =	1014 gal/day	30,415 gal/month		364,976 gal/yr	
Average Storage =	2,285 gallons				
Median Storage =	3,000 gallons				
Storage was Dry =	64 months	22%			
Storage < 100 gal =	65 months	23%			
Average Supplemental Water =	40 gal/day	1,197 gal/month		14362 gal/yr	
Median Supplemental Water =	0 gal/day	0 gal/month		0 gal/yr	
Total Supplemental Water =	343,489 gallons				

## Section 8 – Design of a Windmill System

Design values for average wind speed can be determined from a network of weather stations across North Dakota that are part of the North Dakota Agricultural Weather Network (NDAWN). Based on parameters selected, corresponding average wind speed values are downloaded from the NDAWN website into the design tool.


Optimum tower siting is determined by the location of the windmill with respect to the surrounding structures and the prevailing wind direction. To obtain optimum performance, the windmill should be located 400-ft from the nearest structure and the top of the tower should be 15-ft taller than the surrounding structures.

Statewide windspeed values can be chosen or a specific value for a selected NDAWN station can be used. A user inputted value can also be directly entered. The following steps are a guide for the Wind Resource tab of the workbook. Clicking on the Windmill Diagram will provide a diagram of a typical windmill.

### 8.1 – Calculating the Required Total Dynamic Head (TDH) for the system

The total dynamic head (TDH) of the windmill can be calculated for a piston pump installation. The location of the watering facility that stores the outputted water also is a factor in determining the required TDH of the system. The following steps are a guide for the TDH tab of the workbook.

- a) Review the **Design Pump Flow Rate**
  - i. See **Section 4.1** for the process of determining this value; if a change is necessary.
- b) Review the **Water Surface Elev. When Pumping (WS)**
  - i. WS is the water surface elevation of the water source when pumping and is populated from the entry on the ENG-39 tab. See **Section 3.2, Step (i)**.
- c) **Is water being pumped out of a well?** Select **Yes** or **No** from the dropdown menu.
  - i. **Yes** – Enter the **Ground elev. at well (W\_Elev)**; skip to **Step (g)**.
  - ii. **No** – will not be used for windmills
- d) **Is the storage located near the well/pump outlet?** Select **Yes** or **No** from the dropdown menu.
  - i. **Yes** – Enter the **Height above ground to inlet of storage (HT)**; skip to **Step (j)**.
  - ii. **No** – Enter the **Height above ground to inlet of storage (HT)**; continue to **Step (h)**.
- e) Enter the **Distance from well to storage (DS)** for a storage tank located remotely.
- f) Enter the **Ground elev. at storage (S\_Elev)** for a storage tank located remotely.
- g) Review the calculated **Total Vertical Lift (VL)**.
  - i. For a storage located near a well;  $VL = W\_Elev - WS + HT$
  - ii. For water storage located remotely from a well;  $VL = S\_Elev - WS + HT$

	<b>United States Department of Agriculture</b>	ND Stockwater Design Version: 4.2 North Dakota	
<b>TOTAL DYNAMIC HEAD AND HYDRAULIC WORKLOAD FOR A WINDMILL SYSTEM</b>			
Producer:	Farmer Bob	Field Office:	Hettinger
Designed by:		Date:	
Checked by:		Date:	
Design Pump Flow Rate: <span style="border: 1px solid black; padding: 2px;">0.7</span> gpm    Is water being pumped out of a well? <span style="float: right; border: 1px solid black; padding: 2px;">Yes</span> Water surface elev. when pumping (WS) = <span style="border: 1px solid black; padding: 2px;">1500</span> MSL Ground elev. at well (W_Elev): <span style="border: 1px solid black; padding: 2px;">1575</span> MSL			
Is the storage located near the well? <span style="float: right; border: 1px solid black; padding: 2px;">Yes</span> Height above ground to inlet of storage (HT) = <span style="border: 1px solid black; padding: 2px;">7</span> ft Total Vertical Lift (VL): W_Elev - WS + HT = <span style="border: 1px solid black; padding: 2px;">82</span> ft      Total Length of Pipeline (LP), ft = <span style="border: 1px solid black; padding: 2px;">17</span>			
Pipe Friction Loss			
Column Pipe Type: <span style="border: 1px solid black; padding: 2px;">1120 - PVC SCH 40</span> Pipeline Type: <span style="border: 1px solid black; padding: 2px;">4710 - SDR 11 - ODC</span> Losses in Pipe Fittings (PFL): <span style="border: 1px solid black; padding: 2px;">0.00</span> ft Column Pipe Size: <span style="border: 1px solid black; padding: 2px;">1 1/4</span> Pipeline Size: <span style="border: 1px solid black; padding: 2px;">1 1/2</span> Column Pipe Losses (CPL): <span style="border: 1px solid black; padding: 2px;">0.51</span> ft    Pipeline Losses (PL): <span style="border: 1px solid black; padding: 2px;">0.00</span> ft Total Friction Loss (TFL): CPL + PL + PFL = <span style="border: 1px solid black; padding: 2px;">0.00</span> ft			
Total Dynamic Head			
TDH: VL + TFL = <span style="border: 1px solid black; padding: 2px;">83</span> ft			
System Layout Summary:	A windmill system to be installed over a well. The windmill system pumps to a storage tank located near the well.		
Hydraulic Workload (HW): <span style="border: 1px solid black; padding: 2px;">96</span> m <sup>3</sup> <small>*Hydraulic Workload: The amount of work required to supply a water demand against a total pumping head (or TDH).</small>			
Comments:			

- h) Review the calculated **Total Length of Pipeline (LP)**.
  - Note:** The pipeline length is only for pipe between the water source and the water storage at the outlet of the pump. Pipeline extending from the outlet of the water storage is to be designed separately.
    - i. For a storage located near a well;  $LP = HT + 10'$  of miscellaneous plumbing between well and storage.
    - ii. For water storage located remotely from a well;  $LP = VL + DS$

**Pipe Friction Loss:**

- i) Select the **Column/Suction Pipe Type** from the dropdown menu.
  - i. For a well; column pipe is the pipe that connects to the pump and is placed down into the well.
    - Typical column pipe is 1120 – PVC SCH 40
- j) Select the **Column/Suction Pipe Size** from the dropdown menu.
  - i. For column pipe; the size depends on the NPT outlet of the pump and typically ranges from 1” to 2”.
- k) Review the calculated **Column/Suction Pipe Losses (CPL/SPL)**.
  - i. The friction loss through the column/suction pipe is automatically calculated by solving for the head loss from the Hazen-Williams equation.
- l) Select the **Pipeline Type** from the dropdown menu.
- m) Select the **Pipeline Size** from the dropdown menu.
- n) Review the calculated **Pipeline Losses (PL)**.
  - Note:** The pipeline length is only for pipe between the water source and the water storage at the outlet of the pump. Pipeline extending from the outlet of the water storage is to be designed separately.
    - i. The friction loss through the pipeline is automatically calculated by solving for the head loss from the Hazen-Williams equation.
- o) Review the calculated **Losses in Pipe Fittings (PFL)**.
  - i. The friction loss is for the piping at the well. Default fittings and values are included in a chart located to the right of the data sheet. The fitting’s size is assumed to be the same as for the **Pipeline Size**. At the very least, the fitting’s material should be changed; as needed.
  - ii. The friction loss through the fittings is automatically calculated by solving for the head loss from the Hazen-Williams equation.
- p) Review the **Total Friction Loss (TFL)**.
  - i. The total friction loss through all piping between the pump and the water storage.
  - ii. For a pump within a well;  $TFL = CPL + PL + PFL$

**Total Dynamic Head:**

- q) Review the calculated **Total Dynamic Head (TDH)**.
  - i. The total head the pump has to work against to deliver the required flow rate  $Q_{Inso}$ .
  - ii.  $TDH = VL + TFL$
  - iii. **TDH** is one of the characteristics to be used in the evaluation and selection of the windmill.

Select Fittings for Plumbing Within Well Pit / Pump House			
Type	Material	Quantity	Head Loss (ft)
Elbow-90 deg	Steel	4	0.29
Standard Tee	Steel	1	0.05
Gate Valve	Steel	1	0.02
Check Valve	Steel	1	0.24
Pipe Fitting Loss (ft):			0.61

## 8.2 – Windmill Sizing Calculator / NDAWN Wind Data Download

- a) Select a **NDAWN Station** from the dropdown list that is nearest to the project site.
- b) **Data Frequency** is monthly.
- c) Select the **Length of Data Record** from the dropdown list for the time frame of data downloaded from the NDAWN station.
  - i. A data frequency of **monthly** gives the following options:
    - **Period of Record**
      - Sets to download all months of the selected **NDAWN Station**'s period of record up to the current previous month.
    - **Last Two Years**
      - Sets to download all months from the previous 2 years starting with the current previous month for the selected **NDAWN Station**.
    - **Beginning Month and Year**
      - Select the **Beginning Month #** from the dropdown menu.
      - Enter the corresponding year (i.e. 2007) for the selected **Beginning Month**.

**WINDMILL SIZING CALCULATOR / NDAWN WIND DATA DOWNLOAD**

Producer:	Farmer Bob	Field Office:	Hettinger
Designed by:		Date:	
Checked by:		Date:	

**NDAWN Website for Data Download:**

https://ndawn.ndsu.nodak.edu/table.csv?station=78&variable=mdvrs&years=2024&type=monthly&quick\_pick=2\_g

\* Please use the options below to determine the local wind average value for the project.

<b>NDAWN Station:</b> <input type="text" value="Ada"/>	<input type="button" value="Get NDAWN Data"/>	<input type="button" value="Windmill Diagram"/>
<b>Data Frequency:</b> <input type="text" value="monthly"/>	* The entered data is valid for the selected NDAWN Station.	
<b>Length of Data Record:</b> <input type="text" value="Last Two Years"/>		
<b>Month to Analyze:</b> <input type="text" value="October"/>	<b># of months:</b> <input type="text" value="2"/>	
<b>Data Statistics:</b> <input type="text" value="Average"/>		
<b>Wind Value:</b> <input type="text" value="8.57 mph"/>	<b>Stroke:</b> <input type="text" value="Short"/>	<b>Wheel Diameter in Feet:</b> <input type="text" value="14"/>
<b>Flow Rate Required to Achieve Daily Water Requirements of the herd in 24 hours:</b> <input type="text" value="0.7 gpm"/>	<b>Velocity of 8.57 mph:</b> <input type="text" value="42 gph"/>	<b>Based on Average Wind Velocity of 8.57 mph:</b> <input type="text" value="89 gph"/>

<b>Planned TDH:</b> <input type="text" value="83 ft"/>	<b>Max Pumping Level for 5/8" Fiberglass:</b> <input type="text" value="714 ft"/>	<b>Max Pumping Level for 3/4" Wood/Steel Fiberglass Rod:</b> <input type="text" value="683 ft"/>	<b>Level for Rod:</b> <input type="text" value="610 ft"/>
<b>Height of existing / planned windmill structure in ft:</b> <input type="text" value=""/>			

Month	Wind Value	Velocity
March	3.35	3.44
April	11.19	
May	3.26	
June	7.70	
July	5.30	
August	6.08	
September	6.77	
October	6.57	

**Comments:** Optimum tower siting is determined by the location of the windmill with respect to the surrounding structures and the prevailing wind direction. To obtain optimum performance, the windmill should be located 400-ft from the nearest structure and the top of the tower should be 15-ft taller than the surrounding structure.

- d) Click the  button to download the data table from the NDAWN website for the parameters set in **Step (c)**.
  - i. Internet access is required for the download to execute.
  - ii. The URL for the website where the data table is downloaded from is located at the top of the Solar Resource tab under the heading **NDAWN Website for Data Download**.
  - iii. The downloaded data is transferred into the workbook and can be viewed in the Solar Data tab.
  - iv. A message in red appears when the **NDAWN Station** is changed and is different than the data currently loaded in the Wind Data tab.
    - \* **NDAWN Station has changed. Please click on Get NDAWN Data button to download the Station data.**
  - v. A message in red appears when inputs for **Data Frequency** and **Length of Data Record** are changed.
    - \* **Data inputs have changed. Please click on the Get NDAWN Data button to update values.**
- e) Select the **Month to Analyze** from the dropdown menu.
  - i. Either a **# of months** or **# of days**, depending on the **Data Frequency** selected, will be calculated from the data downloaded and located in the Wind Data tab.
- f) Go to the Windmill Data sheet to determine the Stroke, Cylinder Dia and Wheel Dia
  - i. Select Stroke from the dropdown. Long or Short
    - If the windmill is set up short stroke, the windmill pumping depth will be increased by 33% and the windmill pumping capacity will be reduced by 25%.
  - ii. Select Cylinder Dia in from the dropdown: options range from 1 ¾" to 8" Go to
  - iii. Select Wheel Diameter in Feet from the dropdown: options include: 6,8,10,12,14, 16
- g) Enter the height of existing /planned windmill structure, in feet
  - i. To obtain optimum performance, the windmill should be located 400-ft from the nearest structure and the top of the tower should be 15-ft taller than the surrounding structures.

h) Review the calculated **Flow Rate Required to Achieve Daily Water Use Given the Requirements of the herd in 24 hours**

i. The resulting flow rate, in gallons per minute (GPM), that the pump and windmill has to meet in order to supply the daily water requirements of the livestock determined on the ND-ENG-39 tab.

i) A table is provided in the lower right hand corner of the data sheet that lists the average wind values and resulting required flow rate for the months of March – October for the selected **NDAWN Station**.

i. The table is only applicable for a **Data Frequency** of **monthly** and a **Length of Data Record** set to **Period of Record**.

Change to monthly, Period of Record, and Average to determine the grazing season values for the selected NDAWN		
Month	Wind Value	Yearly Ave
March	9.28	8.40
April	11.38	
May	8.88	
June	7.41	
July	6.70	
August	6.74	
September	7.29	
October	7.80	

j) A comments section is available at the bottom of the data sheet for documentation of design decisions and justifications for values used.

k) Review the Requirements of the herd in 24 hours (WU/24), in gallons per hour. The Est. Production of windmill based on Average Wind Velocity of 0 miles per hour, MPH. This value must be larger than the requirements of the herd in 24 hours. If it is not a message will display **The current windmill configuration will not meet the planned TDH requirements.**

l) Review the planned TDH for the system and max pumping levels to see if the windmill design is a viable option for the system. The row in which the calculated HW falls is highlighted green, yellow, or red.

i. If Max Pumping Level is > the planned TDH then it is a properly sized, wind system is adequate.

- Row is highlighted **GREEN**

ii. If Max Pumping Level is < then the system will not meet the planned TDH and will need to be changed

- Row is highlighted **RED**

## Section 9 – Construction Package

### 9.1 – Construction Package Requirements

The creation of a complete construction design package is not only an example of good engineering practice it is NRCS policy. The National Engineering Manual (NEM) Part 511 – Design, Subpart A – Procedures, Section 511.08 – Construction Plans states: (a) “The preparation of construction plans is the final step in the design process. The construction plans consist of drawings and specifications. The drawings are a graphical description and the specifications are the narrative description of the works to be constructed. The plans are to provide descriptive information on the quantity and quality of the completed work. The work is to be clearly described so that the owner and constructor will understand the requirements. This provides a mutual understanding when the requirements are met.” The required content of the drawings and specifications are further defined in the NEM under Part 541 – Drafting and Drawings, Section 541.6 – Style and Content and Part 542 – Specifications, Subpart A – Section 542.01 – Scope; respectively. The design workbook is set up to create a complete construction design package including a coversheet, a design plan sheet, pipeline profile sheet(s), a set of engineering standard drawings, and a set of conservation practice specifications and O&Ms.

### 9.2– Coversheet

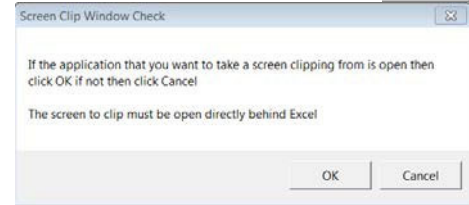
A coversheet details the content of a construction package. The coversheet produced by the design workbook includes a project location map, general construction notes, an index of drawings contained in the package, a summary of engineering job approval authority for the project, and a NRCS Practice Certification Statement for construction checkout. The coversheet also includes a North Dakota county map that highlights the county where the project is located. A large majority of the coversheet is automatically updated with information entered and calculated throughout the design workbook.

- a) Verify the title information and the state county map on the coversheet
  - i. Make any necessary changes on the Title Page tab of the workbook; see **Section 2.4 – Title Page**
- b) Import a project location map
  - i. A map is inserted by performing a screen clip of an existing document. The application or document that the map is to be taken from must be open and visible directly behind the Excel workbook.



- ii. Click the **Clip Location Map** button to insert a map
  - A message is displayed informing the user of the screen clipping procedure.
  - Click **OK**
  - Excel will minimize and the screen turns into screen clip mode.
  - Left click the mouse and drag a box around the desired map to import.
- iii. Resize the map as necessary

**Clip Location Map**



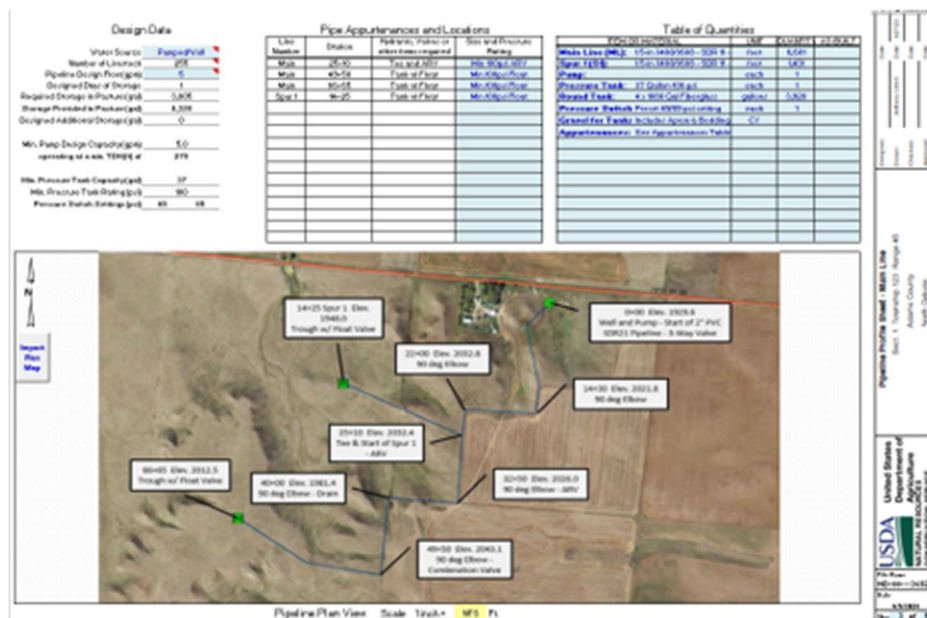
- c) Enter the pipeline burial depth in Item 4 of the general Construction Notes
- d) Verify the drawing information in the Index of Drawings table
  - i. See **Section 7.5 – Drawings and Documents** for the selection of standard drawings to include in the construction package.
  - ii. Edit drawing names as necessary.
- e) Review the Engineering Job Approval Authority (EJAA) table
  - i. The EJAA table is automatically populated with the design values from the appropriate design tabs and the corresponding EJAA class value.
- f) The NRCS Practice Certification Statement is filled out after the project has been completed. A person with the appropriate level of EJAA for construction checkout signs and dates the statement acknowledging that the practice(s) meet NRCS drawings and specifications.
- g) A default Construction Drawing Number is created and shown in Cell Y55.
  - i. Default Number: two letter state code – year of design – designer initials – design Julian date
  - ii. This can be overridden with a user defined name in Cell AD55


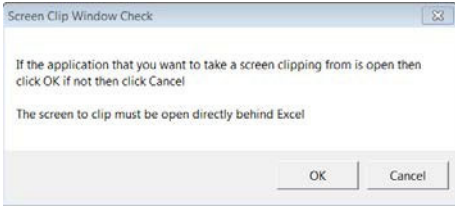
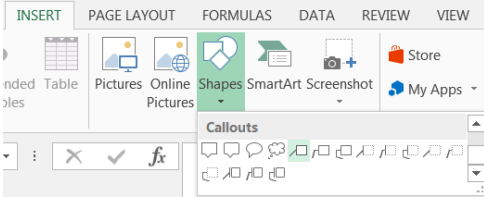

Recommended Construction Drawing Format
ND-Year-Initials-Julian Date (Default)
(User Defined)

### 9.3– Design Plan Sheet

A design plan sheet provides a summary of the designed system. The design plan sheet produced by the design workbook includes a plan map, a design data summary of the practices planned, a table of planned pipeline appurtenances, and a table of quantities. A large majority of the design plan sheet is automatically updated with information entered and calculated throughout the design workbook.

Plan maps are a key piece of information for the landowner and installing contractor. The map should provide an overall layout of the watering system and show the locations of major system components; i.e. well, spurs, valves, tanks, etc. It is important that the maps are labeled so these features can be clearly identified and located.



- h) Review the summary of the design data for the practices planned
  - i. Information will vary depending on what components of the watering system are being designed.
    - Pump and pressure tank data are not visible when they are not planned.
  - ii. Make any necessary changes by returning to the appropriate workbook tab.
- i) Enter a description of the Water Source in Cell E4
- j) Enter the Pipeline Design Flow (gpm) of the system in Cell E6
- k) Import a project plan map
  - i. A map is inserted by performing a screen clip of an existing document. The application or document that the map is to be taken from must be open and visible directly behind the Excel workbook.
 
  - ii. Click the **Import Plan Map** button
    - A message is displayed informing the user of the screen clipping procedure.
    - Click **OK**
    - Excel will minimize and the screen turns into screen clip mode.
    - Left click the mouse and drag a box around the desired map to import.
  - iii. Resize the map as necessary
- l) Create labels for the Plan Map if not previously labeled before the import
  - i. From the INSERT toolbar and Illustrations, select a Callout from the Shapes dropdown list.
  - ii. Click within the plan map to place the label in the appropriate location.
  - iii. Click on the placed label and type in the desired label information
    - At a minimum, include the stationing and description of the feature to be installed.
- m) Review the Pipe Appurtenances and Locations table
  - i. The table is automatically populated with the appurtenance information entered on the pipeline Profile tabs
    - Make any necessary changes by returning to the appropriate pipeline Profile tab; see **Section 5.5 – Pipeline Profiles**.
- n) Enter the Size and Pressure Rating of each listed appurtenance
  - i. It is important to be aware of the maximum system operating pressures and ensure that all appurtenances have an adequate pressure rating.
- o) Click on the **Populate Table of Quantities** button
  - i. The Table of Quantities is populated with a list of system components and their respective quantity as calculated from data throughout the design workbook.
 
- p) Review all populated items in the Table of Quantities
  - i. All items in the table are editable
    - Make any edits or provide descriptions as necessary
  - ii. Add any addition Items or Material, including units and quantity, required in the installation of the watering system.

#### 9.4–ND-ENG-1; Construction Specifications Cover Sheet

The ND-ENG-1 Construction Specification Cover Sheet provides an overview of what supporting documentation is contained within the design package. The ENG-1 also reviews and explains the procedure for obtaining and documenting the required utility safety One-Call ticket number.

- q) Enter a brief Job Description summary of the planned stockwater system in Cell C8
- r) Review the drawing populated drawing information
- i. The Construction Drawing Number is automatically created on the Coversheet tab; see **Section 7.2 g)**
  - ii. Number of Sheets is the total number of design and standard drawings contained in the construction package.
- s) Enter the name of the person with the appropriate Engineering JAA that is approving the complete design suite of practices and the date of approval.
- t) Practice Specification Table
- i. Populate the specification table by selecting the appropriate practice specifications and O&Ms on the Drawings tab
    - See **Section 7.5 – Drawings and Documents**
  - ii. Return to the ND\_ENG\_1 tab
- u) Select the checkbox for any Additional Items that are included in the construction package
- i. Several boxes are automatically checked when certain conditions are met.
    - Inclusion of O&M Plans
    - Class IV or greater jobs
- v) Review the landowner utility One-Call information and ensure that all signatures and ticket numbers are obtained after print out of the construction package.

U.S. DEPARTMENT OF AGRICULTURE  
NATURAL RESOURCES CONSERVATION SERVICE  
NORTH DAKOTA  
CONSTRUCTION SPECIFICATIONS COVER SHEET

**ND-ENG-1**

Producer: Farmer Bob      Field Office: Hettinger  
Location: Sect. 1 Township 123 Range 45      Contract #:  
Job Description:

---

**Drawings and Specifications**

Construction Drawing Number: ND-00-36525      Number of Sheets: 5

Approver Signature: \_\_\_\_\_      Date: \_\_\_\_\_  
Design Approved By: \_\_\_\_\_

	Document Name
ND-CS-100	General Requirements
ND-CS-516	Livestock Pipeline
ND-CS-533	Pumping Plant
ND-CS-614	Watering Facility
ND-CS-642	Water Well
ND-OM-516	Livestock Pipeline
ND-OM-533	Pumping Plant
ND-OM-614	Watering Facility
ND-OM-642	Water Well

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**Additional Items**

Grass/Legume Seeding Job Sheet       Inspection Plan (Job Class IV or greater)  
 Design Report (Job Class IV or greater)       Second Page of Documents Attached  
 Other: \_\_\_\_\_

**Owner/Operator/Producer Review**

I have reviewed the drawings, construction specifications, and additional items listed and I agree to construct, operate, and maintain this project in accordance with them. I understand that modifications during construction will require approval from the NRCS prior to installation. I agree to obtain all necessary permits, easements, and water rights. I will inform the NRCS of all conditions pertaining to project construction as stated in the acquired permits. I agree to comply with all federal, state, tribal, I have received a copy of the operation and maintenance plans. I will conduct the maintenance of the installed work as it is necessary for proper performance during the life of the practice.

I agree to take the necessary precautions to prevent personal injuries and damage to utilities from accidental contact. The NRCS makes no representation of the existence or non-existence of any utility. Any individual(s) performing excavation work is responsible for calling 811 or the ND One Call Center at (1-800-795-0555) at least two working days before work begins to have all publicly owned utilities marked. If excavation has not occurred within 21 days of obtaining a One-Call excavation ticket <https://www.ndonecall.com/>

I understand that it is my responsibility to provide the One-Call ticket number(s) to NRCS prior to any ex

Owner/Operator/Producer Signature \_\_\_\_\_      Date \_\_\_\_\_  
I verify that the documents listed above have been discussed with the owner/operator/producer and that they have received a copy of the files

---

Reviewed by NRCS Representative	Date	One-Call Ticket Number(s) Received by NRCS
USDA-NRCS-ND	ND-ENG-1	0216/24

## 9.5–Drawings and Documents

The creation of the construction package relies on the download of documents from the North Dakota NRCS Engineering Website. If not previously done, please refer to **Section 2.3 –Workbook Setup** to complete the document download.

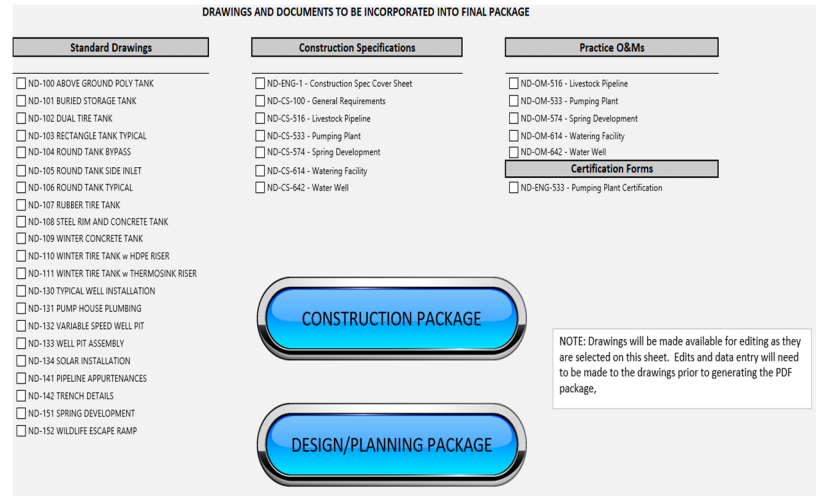
The stockwater design construction package is assembled through the combination of three files. The files are created by the design workbook through the generation of two packages: a Construction Package and a Design/Planning Package. The Construction Package contains the design drawings and construction specifications. The Design/Planning Package contains the design data sheets and can be generated independently from the Construction Package and used during the planning process. During the creation of the packages, the producer’s first and last name is automatically added to the end of the file name to allow for easy file management. Each file is produced as a single PDF document and contains the documents as shown below:

- Design Drawings
  - Coversheet
  - Design Plan Sheet
  - Pipeline Profile Sheet(s)
  - Set of applicable engineering standard drawings
- Design Data Sheets
  - Title Page
  - ND-ENG-39
  - Pipeline Hydraulic Computation
  - Pump Sizing
  - Pressure Tank Sizing
  - Pipeline Design Final TDH Check
  - System and Pump Curve

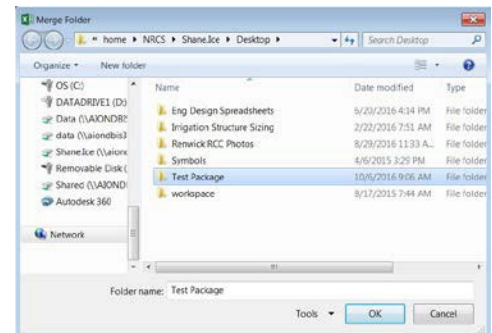
- Construction Specifications
  - ND-ENG-1
  - Set of applicable construction specifications
  - Set of applicable operation and maintenance (O&M) plans
  - Set of applicable certification forms

On the Drawings tab:

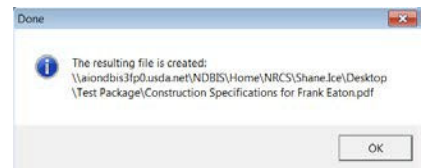
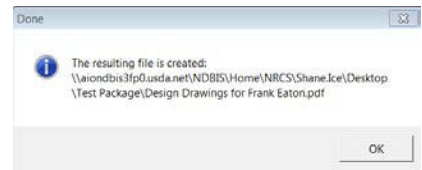
- As drawing sheets are selected, an associated tab will become visible from which the user can review the drawing and enter any appropriate design information in available text boxes.
- Select the appropriate practice construction specifications to be included in the construction package
- Select the appropriate practice operation and maintenance (O&M) plans to be included in the construction package
- Select the appropriate engineering forms to be included in the construction package



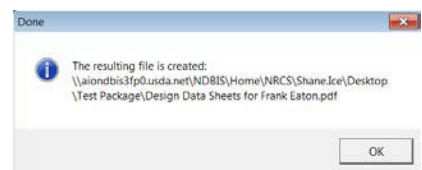
- Click the **Generate Construction Package** button
    - A Windows Explorer box appears
      - Navigate to and choose a file folder to save the generated packages
        - Select the folder only; do not open the folder
      - Click **OK**
      - A message appears stating that the Design Drawings file has been created.
      - A message appears stating that the Construction Specification file has been created.
    - Review the list of drawings and documents included in the generated package



- Click the **Generate Design/Planning Package** button
    - A Windows Explorer box appears
      - Navigate to and choose a file folder to save the generated packages
        - Select the folder only; do not open the folder
      - Click **OK**
      - A message appears stating that the Design Data Sheets file has been created.



- Open Windows Explorer and navigate to the folder where the packages have been saved
- Review the content of each file generated
  - Complete the Items of Construction Detail for all appropriate construction specifications with any additional information specific to the design.



APPENDIX

Appendix 1 – Pipeline Tables

		INSIDE DIAMETER FOR PIPE					
		34093608 - SOR 7 - CDC	34093608 - SOR 9 - CDC	34093608 - SOR 11 - CDC	34093608 - SOR 13.5 - CDC	34093608 - SOR 15.5 - CDC	34093608 - SOR 17 - CDC
1	0.917	0.933	1.005	1.062			
1.14	1.157	1.178	1.259	1.340			
1.12	1.325	1.348	1.452	1.534			
2	1.656	1.685	1.816	1.917	2.002	2.050	2.079
2.12	2.440	2.484	2.676	2.825	2.950	3.021	3.064
3	3.137	3.193	3.440	3.633	3.793	3.885	3.939
4	4.619	4.701	5.064				

		PRESSURE RATING FOR PIPE					
		34093608 - SOR 7 - CDC	34093608 - SOR 9 - CDC	34093608 - SOR 11 - CDC	34093608 - SOR 13.5 - CDC	34093608 - SOR 15.5 - CDC	34093608 - SOR 17 - CDC
1	267	264	200	160	133	110	100
1.14	267	264	200	160	133	110	100
1.12	267	264	200	160	133	110	100
2	267	254	200	160	128	110	100
2.12	267	254	200	160	128	110	100
3	267	254	200	160	128	110	100
4	267	254	200	160	128	110	100
6	267	254	200	160	128	110	100

		4770 - SOR 7 - CDC	4770 - SOR 9 - CDC	4770 - SOR 11 - CDC	4770 - SOR 13.5 - CDC	4770 - SOR 17 - CDC	4770 - SOR 19 - CDC	4770 - SOR 21 - CDC
1	0.916	1.005	1.061	1.109				
1.14	1.158	1.270	1.340	1.399				
1.12	1.325	1.453	1.601					
2	1.656	1.815	1.917	2.002	2.078			
2.12	2.440	2.675	2.826	2.951	3.063	3.110	3.146	
3	3.137	3.440	3.633	3.794	3.938	3.998	4.046	
4	4.619	5.065	5.349	5.584	5.798	5.885	5.957	

		4770 - SOR 7 - CDC	4770 - SOR 9 - CDC	4770 - SOR 11 - CDC	4770 - SOR 13.5 - CDC	4770 - SOR 17 - CDC	4770 - SOR 19 - CDC	4770 - SOR 21 - CDC
1	333	250	200	160				
1.14	333	250	200	160				
1.12	333	250	200	160				
2	333	250	200	160	125			
2.12	333	250	200	160	125	111	100	
3	333	250	200	160	125	111	100	
4	333	250	200	160	125	111	100	
6	333	250	200	160	125	111	100	

		1120 - PVC SOR 1120 - CDC	PVC SOR 1120 - CDC	PVC SOR 1120 - CDC	PVC SOR 1120 - CDC	PVC SOR 1120 - CDC	PVC SOR 1120 - CDC	PVC SOR 1120 - CDC
1	13.5	17	21	26	40	80		
1.14	1.121	1.161	1.189	1.195	1.049	0.957		
1.12	1.414	1.464	1.502	1.532	1.380	1.278		
2	1.618	1.676	1.720	1.754	1.610	1.500		
2.12	2.023	2.095	2.149	2.193	2.067	1.939		
3	2.449	2.537	2.601	2.655	2.469	2.323		
4	2.982	3.068	3.166	3.230	3.068	2.900		
6	3.834	3.972	4.072	4.154	4.026	3.826		

		1120 - PVC SOR 1120 - CDC	PVC SOR 1120 - CDC	PVC SOR 1120 - CDC	PVC SOR 1120 - CDC	PVC SOR 1120 - CDC	PVC SOR 1120 - CDC	PVC SOR 1120 - CDC
1	13.5	17	21	26	40	80		
1.14	315	250	200	160	460	630		
1.12	315	250	200	160	368	520		
2	315	250	200	160	330	470		
2.12	315	250	200	160	277	404		
3	315	250	200	160	303	424		
4	315	250	200	160	263	375		
6	315	250	200	160	222	323		

## Appendix 2 –Solar Design Example

This example uses the ND\_Solar\_Pump design workbook and follows the design steps from North Dakota Technical Note 1 – Design of Small Photovoltaic (PV) Solar-Powered Water Pump Systems.

### Determine:

Design a solar-powered water pump system that consists of a midsize cow/calf operation near Hazen, North Dakota. Determine the size of the system needed, including the pump, piping, PV panels, mounting tilt angle, tank size, etc.

### Given:

- The landowner runs 50 cow/calf pairs on 85 acres of pasture land.
- The landowner intends to use an existing well in the pasture for the water supply.
- The grazing season is planned from March through October.
- The landowner lives nearby and is on site daily for routine maintenance but would like a storage tank sized for a minimum of three days of water storage in the event of extended cloudy weather or maintenance issues that prevent the pump from operating.
- The storage tank is located near the well and the inlet into the tank is 7' above the ground.
- The landowner intends to gravity feed two watering troughs located 1,000ft and 1,150ft from the proposed storage tank.
- Two 500-gallon troughs are to be used. Each trough will be equipped with a float valve that requires 2 psi to operate properly.

### Analysis:

#### **Step 1. Water Requirement**

Use the ENG-39 tab to enter the planned livestock numbers and grazing information as shown:

Type of Livestock	Number of Livestock	Water Requirement	Daily Water Use	Required Drinking Spaces
Beef - Lactating Cow and Calf	50	20 gpd	1,000 gals.	2
		0 gpd	0 gals.	
		0 gpd	0 gals.	
		0 gpd	0 gals.	
<b>Total =</b>			<b>1,000 gals.</b>	<b>2</b>

Grazing Dates Livestock Utilize System: From: March to October  
 Type of Stocking / Grazing System: Range/Pasture with less than 1/2 mile max travel to water  
 Source of Water Supply: Solar

#### **Step 2. Water Source**

A search of the ND Well Data found the well log for the existing well.

The well log contains the following pertinent information with respect to a ground elevation of 1,000ft:

- Depth of Well Below Surface – 285ft
- Static Water Level Below Surface – 190ft
- Dynamic Water Level Below Surface – 70ft of drawdown after 2hrs @ 10gmp (260ft)
  - Elevation = 1,000' – 260' = 740'
- Depth of Pump Below Surface – 275ft

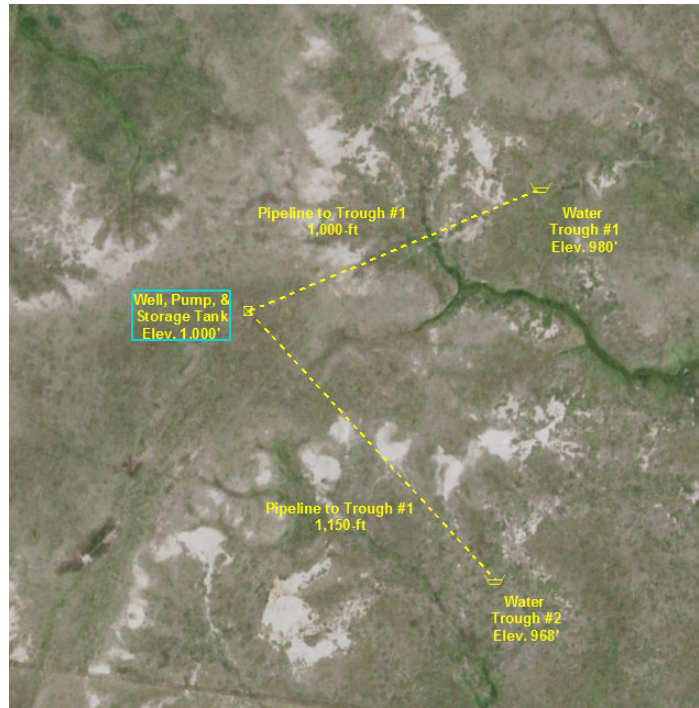
Enter the water source information on the ENG-39 tab as shown:

<b>Source Water Surface Elevation:</b>	740.0	ft	<a href="#">ND Well Data</a>	<a href="#" style="background-color: #4a7ebb; color: white; padding: 5px 15px; border-radius: 5px;">Calculate Well</a>
<b>Source Max Flow Rate:</b>	10.0	gpm		

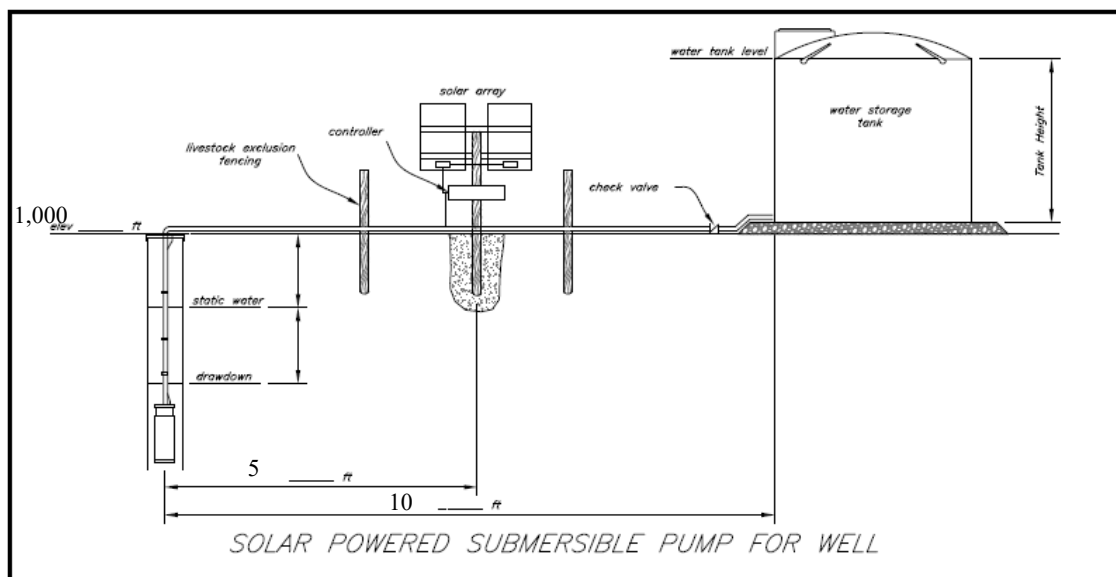
### Step 3. System Layout

The identified distances and elevations for the well, pump, PV panels, storage tank, and water troughs are shown in **Figure A1**. For this example, based on the site-specific data provided in the aerial view, the site has good south-facing exposure and appears well suited for solar power. Flow from the storage tank to the water troughs will be gravity fed. Based on the given elevations, the natural layout of the site appears to provide an adequate elevation difference between the storage tank and the water troughs to operate the tank float valves in the water troughs. In addition, the storage, pump, and PV panels can all be located in close proximity to one other in order to minimize electric power and pipeline friction losses.

**Figure A2** depicts the profile of the proposed layout of the pump and PV panels.



**Figure A1** – System Layout for Design Example.



**Figure A2** – System Layout Profile for Design Example.

Use the given information and enter the watering facility and storage information on the ENG-39 tab as shown:

**Watering Facility Sizing and Delivery Requirements:**

Watering Facility Type:	Perimeter	Volume	# of Facilities	Actual Drinking Spaces
Round	30 ft	500 gals	2	60
Rectangle/Square	ft	gals		
Rubber Tire	ft	gals		
Prefab Drinkers	Rqrd. Drinking Spaces:	of Spaces per Waterer:		
<b>Total Watering Facility Volume (WfV) =</b>				<b>1,000 gals.</b>

Total Daily Water Use (WU): Use 10% for evaporation and spillage?  No   
 $WU = \text{Daily Water Use} = 1,000 \times 1.0 = 1,000 \text{ gals. / day}$

Water Source Also Provide Domestic Use  No

12-Hour Watering System Flow Rate ( $Q_{12}$ ):  $Q_{12} = WU / (12\text{hr/day} * 60) = 1.4 \text{ gpm}$   
 Design Water Delivery Flow Rate (Q): 1.4 gpm Flow Delivery Period: 11.9 hr/day  
 Minimum Pump Flowrate ( $Q_{pump\_min}$ ): 1.4 gpm  
 Design Pump Flow Rate ( $Q_{pump}$ ): gpm  
 \*  $Q_{pump} < Q_{pump\_min}$

Required Days of Storage in Pasture (DSmin): 3 day(s) Design (DS): 3 day(s)  
 Required Storage in Pasture (RS):  $RS = DS \times WU = 3 \times 1,000 = 3,000 \text{ gals.}$   
 Required Additional Storage ( $AS_{min}$ ):  $AS = RS - WfV = 2,000 \text{ gals.}$   
 Design (AS): 2,500 gals.

#### Step 4. Solar Insolation and Solar Array Layout

The closest observed solar insolation values for the project site is from the NDAWN station near Hazen, ND. Given that grazing is planned March – October, the month with the lowest average value, October, will be the target insolation value used for the design.

Using the Hazen NDAWN Station, enter the information on the Solar Resource tab as shown (click the Get NDAWN Data button if station data has not been already downloaded):

\* Please use the options below to determine the local solar insolation value for the project.

NDAWN Station: Hazen

Data Frequency: monthly

Length of Data Record: Period of Record \* The entered data is valid for the selected NDAWN Station.

Month to Analyze: October # of months: 34

Data Statistics: Average

**Total Daily Insolation 2.54 hours/day @ 1-Sun (kWh/m<sup>2</sup>)**

Flow Rate Required to Achieve Daily Water Use Given the Location's Solar Insolation Value ( $Q_{Inso}$ ): Daily Water Use / (Insolation \* 60) = 6.6 gpm \* Production of installed pump and solar array combination to be at least  $Q_{Inso}$ .

#### Step 5. Design Flow Rate for Pump

The pump's design flow rate is based on the operation's estimated daily water needs of Step 1 divided by the number of peak sun hours per day of Step 4. The flow rate is calculated on the Solar Resource tab as shown:

Flow Rate Required to Achieve Daily Water Use Given the Location's Solar Insolation Value ( $Q_{Inso}$ ): Daily Water Use / (Insolation \* 60) = 6.6 gpm \* Production of installed pump and solar array combination to be at least  $Q_{Inso}$ .



Insolation values for other months may be considered if supported by the grazing plan through either adjusted livestock numbers or grazing period or some combination of the two. The decision of which values to use is up to the discretion of the designer and should be based on good engineering judgment and supporting documentation. A table of insolation values and resulting flow rates for each month in a typical grazing season is shown below:

Values of a Typical Grazing Season for the Period of Record of the Hazen NDAWN Station		
Month	Inso Value	Flow Rate
March	3.75	4.44
April	4.88	3.42
May	5.59	2.98
June	6.21	2.68
July	6.58	2.53
August	5.52	3.02
September	4.09	4.07
October	2.52	6.62

### Step 6. Total Dynamic Head (TDH) for the Pump

Using the given planning data and well information, the TDH for the proposed system is calculated on the TDH tab as shown below:

Design Pump Flow Rate: 6.6 gpm Is water being pumped out of a well? Yes

Water surface elev. when pumping (WS) = 740 MSL  
Ground elev. at well (W\_Elev): 1000 MSL

Is the storage located near the well? Yes  
Height above ground to inlet of storage (HT) = 7 ft

Total Vertical Lift (VL): W\_Elev - WS + HT = 267 ft Total Length of Pipeline (LP), ft = 17

**Pipe Friction Loss**

Column Pipe Type: 1120 - PVC SCH 40 Pipeline Type: 4710 - SDR 11 - ODC Losses in Pipe Fittings (PFL): 0.51 ft  
Column Pipe Size: 1 1/4 Pipeline Size: 1 1/2  
Column Pipe Losses (CPL): 1.75 ft Pipeline Losses (PL): 0.07 ft

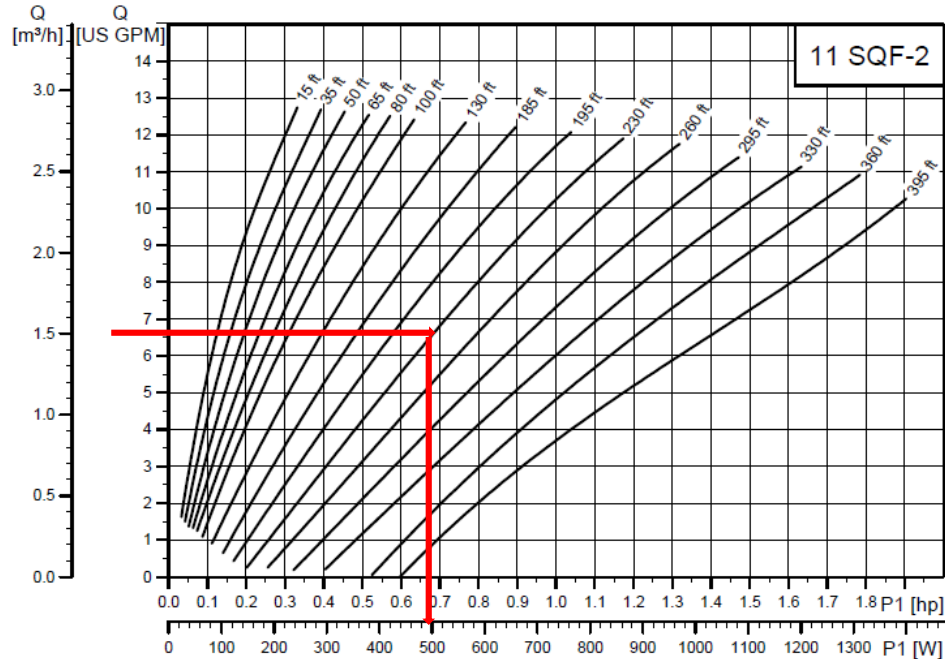
Total Friction Loss (TFL): CPL + PL + PFL = 2.33 ft

**Total Dynamic Head**  
TDH: VL + TFL = 270 ft

### Step 7. Pump Selection and Associated Voltage and Power Requirement

The pump can be selected by comparing the  $Q_{Inso}$  and TDH calculated in Steps 5 and 6 with the information from the manufacturer's pump curves. A Grundfos 11 SQF-2 pump and CU-200 controller combination has been selected for use and the associated pump curve is shown below.

## 11 SQF-2



As on the pump curve, based on a calculated flow rate of 6.6 gpm and a TDH of 270ft, a minimum input of 610 Watts of peak power is required. The pump literature states that the optimal operating voltage for the pump is specified as a 120 volts. The Pump and Array tab of the workbook automatically looks up these values, as well as the pump’s efficiency, based on the selection of the pump brand and model through the use of the tables in the Pump Tables tab.

### Location and Pump Requirement Summary

Solar Insolation Value:  kWh/d    Daily Water Demand (WU):  GPD

Pump Flow Rate from Solar Insolation ( $Q_{griso}$ ):  gpm    Pump Head Requirement (TDH):  ft

### Pump Data

Pump Brand to Evaluate:     Required Pump Input Power ( $P_{in}$ ):  W  
 Grundfos Model #:      kW  
 Pump Efficiency ( $P_{EM}$ ):  <<-- Calculated pump efficiency =  $0.1885 * TDH * Q_{griso}$     HP: 0.81931  
 Pump Operating Voltage ( $P_{vols}$ ):  Volts <<--Grundfos recommends at least 120V for best performance.

## Step 8. PV Panel Selection and Wiring of Solar Array

The PV panels selected for this system must be able to provide the minimum energy requirement to run the pump. As determined in **Step 7**, the minimum power needed is 610 Watts and the voltage requirement is 120 Volts.

A PV panel is selected that has the electrical characteristics shown below: a peak power output of 250 W at a  $V_{mpp}$  of 30.6 V and an  $I_{mpp}$  of 8.17 A.



Entering these values into the Pump and Array tab, the solar array calculates to be composed of 1 string of 4 panels wired in series.

Solar Panel Data			
Brand of Solar Panel:	SunSolar	Max Power (Pmax):	220 Watts
Solar Panel Model #:	SLP(220)	Max Power Voltage (Vmpp):	38 Volts
Example:	BP Solar - BP4175B	Max Power Current (Impp):	5.79 Amps
		Solar Panel De-Rating Value (DRV):	85%
*			
Solar Panels in Series (SP <sub>Series</sub> ): P <sub>Volts</sub> / V <sub>mpp</sub> =	4	# of Series in Parallel (SP <sub>II</sub> ): P <sub>I</sub> / (SP <sub>1,2,3,4</sub> * V <sub>mpp</sub> * Impp * DRV) =	1
Total # Panels in Array (SP <sub>Total</sub> ): SP <sub>Series</sub> * SP <sub>II</sub> =	4		
*			

Given that a single PV panel is rated at 250W, the 4 panel (4 x 250W = 1,000W) will easily meet the 610W requirement of the pump. It is important, however, to make sure that the total power supplied by the solar array does not exceed the maximum rated limit of the pump and controller.

### Step 9. System Production and Flow Rate

Now that the pump requirements and size of the solar array has been determined (Steps 7 and 8; respectively), the actual production and flow rate of the system can be calculated as shown in the Pump and Array tab.

$$\text{Output of Solar Configuration (Q}_{\text{system}}\text{): } (V_{\text{mpp}} * I_{\text{mpp}} * SP_{\text{Total}} * \text{Insolation} * 60 * \text{DRV} * P_{\text{Eff}}) / (0.1885 * \text{TDH})$$

Calculated Q<sub>system</sub>: **1233** GPD

Calculated Flow Rate for Solar Configuration: **8.1** gpm

Note: It is important to check that the actual produced flow rate of the system does not cause velocities within the connecting pipeline to exceed 5ft/sec.

### Step 10. Water Storage

The system's total water storage capacity should be sufficient for a minimum of three days water use. This minimum storage capacity is calculated below using the water requirement derived in Step 1.


$$1,000 \text{ gallons/day} \times 3 \text{ days} = 3,000 \text{ gallons}$$

Two 500-gallon water troughs are included in the system, providing a total storage capacity of 1,000 gallons (2 x 500 = 1,000). Therefore, the storage tank must be sized to hold a minimum of 2,000 gallons (3,000 – 1,000 = 2,000). Based on information from different distributors, a 2,500-gallon water tank is a readily available size. A common tank of this size is



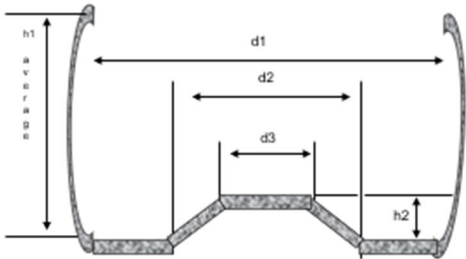
### Appendix 3 –Rubbertire Tank Calculator Form

This form is found on the Rubbertire Tank Checkout tab. It can be used for the checkout of three rubber tire tanks. Enter the dimensions as show in the figure to calculate the total gallons of the tank. A space is provided next to the word tank to add a number or contract item number. A space for comments is provided at the bottom of the sheet.

	United States Department of Agriculture	<input type="button" value="Clear Data"/>	ND Stockwater Design Version 4.2 North Dakota
<b>RUBBERTIRE TANK CALCULATION FORM</b>			
Producer:	Farmer Bob	Field Office:	Hettinger
Contract No.:		CIN:	
Location:	Section 1 Township 123 Range 45	Fields:	
Computed By:		Date:	
Checked by:		Date:	

**TIRE CASING DIMENSIONS (FT)**



The diagram shows a cross-section of a rubber tire tank. It is a trapezoidal shape with a curved top. The top width is labeled d1. The width of the upper straight section is labeled d2. The width of the lower straight section is labeled d3. The height of the upper section is labeled h1. The height of the lower section is labeled h2.

TANK CAPACITY = (0.785)  $\left[ \frac{d_1^2 h_1}{4} - \frac{(d_2 + d_3)^2 h_2}{16} \right]$

Tank: <input type="text"/>	d1=	<input type="text"/>	d2=	<input type="text"/>	d3=	<input type="text"/>
Dimensions	h1=	<input type="text"/>	h2=	<input type="text"/>		
		23.5	X	0		0
		<u>0 GALLONS</u>				
Tank: <input type="text"/>	d1=	<input type="text"/>	d2=	<input type="text"/>	d3=	<input type="text"/>
Dimensions	h1=	<input type="text"/>	h2=	<input type="text"/>		
		23.5	X	0		0
		<u>0 GALLONS</u>				
Tank: <input type="text"/>	d1=	<input type="text"/>	d2=	<input type="text"/>	d3=	<input type="text"/>
Dimensions	h1=	<input type="text"/>	h2=	<input type="text"/>		
		23.5	X	0		0
		<u>0 GALLONS</u>				

Comments:

## Appendix 4 –How to Review Local Well Logs

The following instructions provide guidance on how to access the recorded well logs for the state of North Dakota. This information is maintained and hosted by the Department of Water Resources (DWR). Well logs near a site can be examined to determine the anticipated conditions for the project site. This information should only be considered approximate as actual site conditions may vary. In addition to surrounding well logs, the DWR has published Ground Water Studies for the state that can be reviewed for further evaluation of the site.

Step 1. Visit the ND Department of Water Resources Mapservices  
[https://www.dwr.nd.gov/info\\_edu/map\\_data\\_resources/mapservices.html](https://www.dwr.nd.gov/info_edu/map_data_resources/mapservices.html)

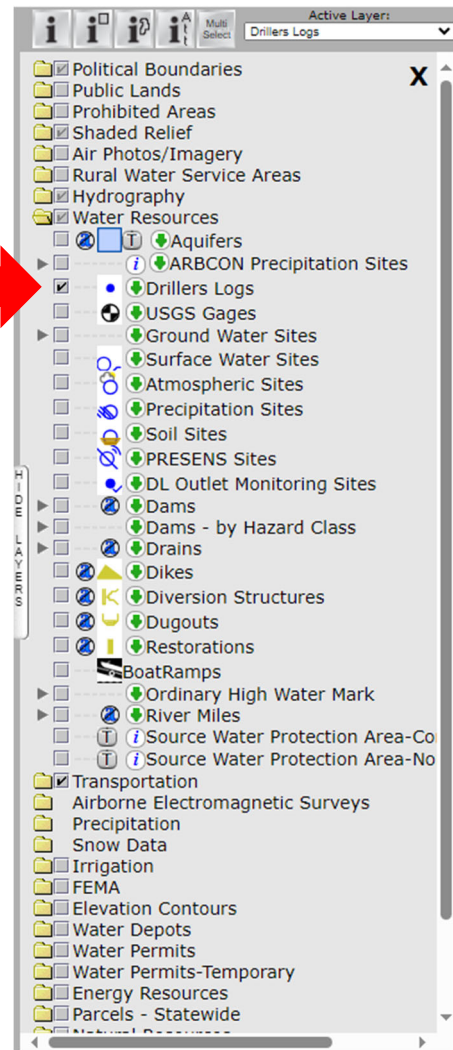
Step 2. Scroll through the available maps and select the “Well Drillers Logs” This will open an interactive map that includes all register wells in the state.

The screenshot displays the ND DWR Mapservices website interface. On the right side, there is a vertical list of blue navigation buttons: Construction Permits, Drains, Government Surveys, Water Resource Sites, Lake Levels, MapServices, ARBCON Precipitation, Private Contractor Logs, Published Maps, Radar - Bowman, Radar - Stanley, Radar - Williston, Retention Structures, Converter Tools, Temporary Water Permits, Water Permits, and Water Depot Login. The main content area is divided into three sections by horizontal lines:

- GROUND AND SURFACE WATER INFORMATION**: Includes a thumbnail image of a map with various colored markers and a text description: "This mapping application allows users to get information about water wells drilled in North Dakota."
- WELL DRILLERS LOGS**: Includes a thumbnail image of a map with blue markers and a text description: "This mapping application provides access to the Board of Water Well Contractors drillers' reports. Well drillers' reports are required to be filed with the State Board of Water Well Contractors within 30 days after completion or abandonment of a well."
- WATER PERMIT INFORMATION**: Includes a thumbnail image of a map and a text description: "This mapping application allows users to get information about permits throughout ND."

Step 3. On the right side of the map is a “layer” index that allows different layers to be turned on and off. On the “Water Resources” layer, the “drillers Loges” layer is turned on. Wells are displayed as blue dots on the map.

Box must be checked to display wells



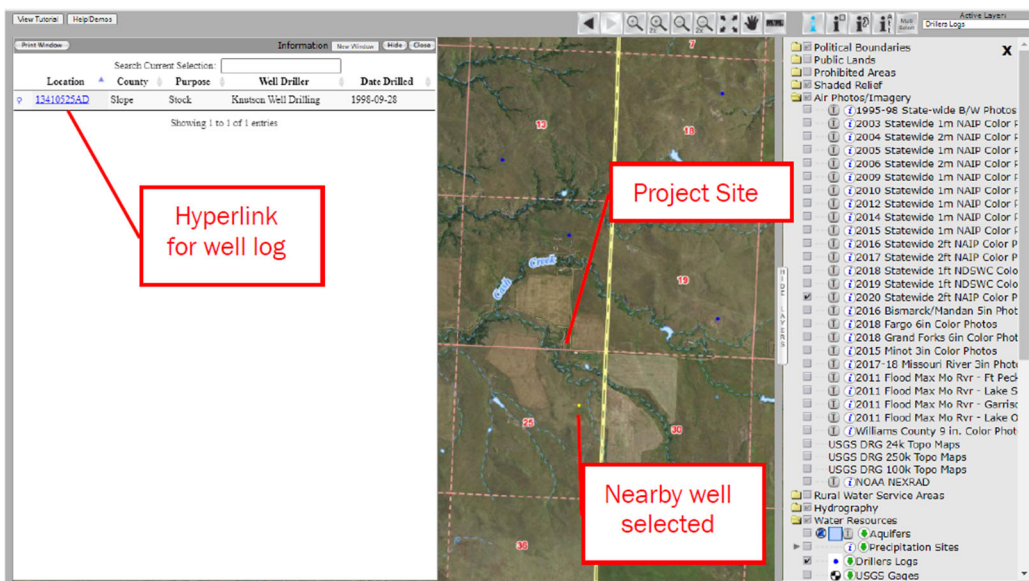
\*Note: Other layers can be toggled on and off to change map display

Step 4. Using the cross-hair cursor, zoom into the general site area by drawing a box around an area that includes the project site. The toolbar along the top of the map allows the user to change the cursor function (zoom in, zoom out, pan, etc.). User can hover over each for a brief description of each function.

a. On this toolbar is also a drop-down for the active layer. Ensure that “Drillers Logs” is selected



Step 5. Ensure that the “Information” icon is selected for cursor function (looks like a lowercase “i”). Locate nearby well(s) and select the blue dot to bring up an information window. This window will include a blue hyperlink that will open a pdf of the corresponding well log.



a. Select the hyperlink and review the associated well log. Identify key features such as well depth, static water level, dynamic water level, tested flow rate, etc.

**Static Water Level**

**Dynamic Water Level**

**Tested Flow Rate**

**Total Well Depth**

Note that the levels are given as depths relative to ground surface. In order to correlate to the project site, an elevation should be determined by obtaining a ground elevation of the selected well and subtracting the depth. This can be done utilizing LiDAR surface data or other appropriate data sets.

Step 6. Repeat this process for other surrounding wells if available.

Step 7. Designer should decide if the obtained information is reasonable to use for the project site. If no wells exist in the general vicinity and/or additional information is required, consider reviewing the Ground Water Studies that have been published by the Department of Water Resources. The county specific reports can be access through their website.



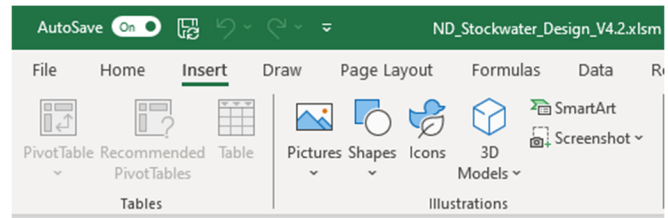
## Appendix 5 –How to Add Stationing to Plan View

The following instructions provide guidance on how to add stationing data to a plan view map in the ND Stockwater Design Workbook. Plan view images can be inserted into the tool using the included buttons. However, many of the images brought in do not have stationing values included, as required by agency policy. Stationing labels can be easily added using the “Callout” shapes within the Excel program.

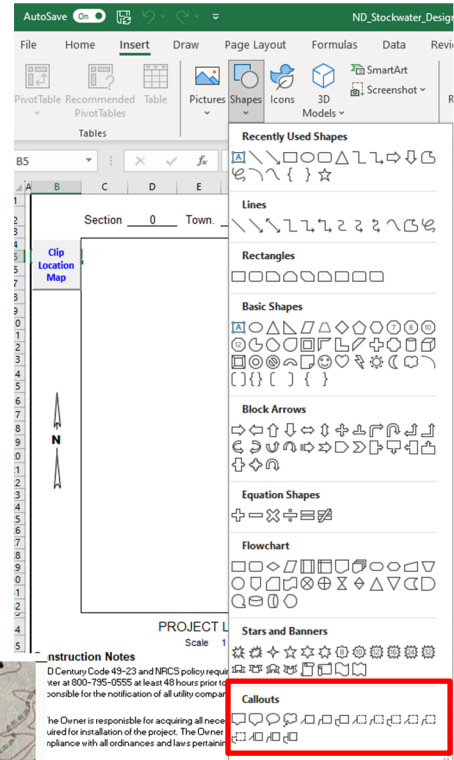
Step 1. Insert a Plan View map onto the “Design Plan” sheet using the included “Import Plan Map” button. See the ND Stockwater Design User Guide for further instructions.

Step 2. Once a plan map has been inserted showing the pipeline route, stationing can be added using Excel tools.

a. On the ribbon, select the “Insert” tab

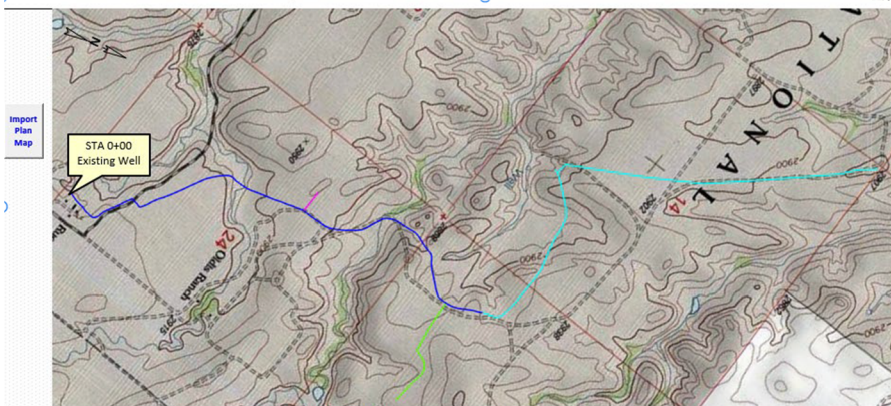


b. On the “Insert” tab, select the “Shapes” drop down and select a “Callout” shape.

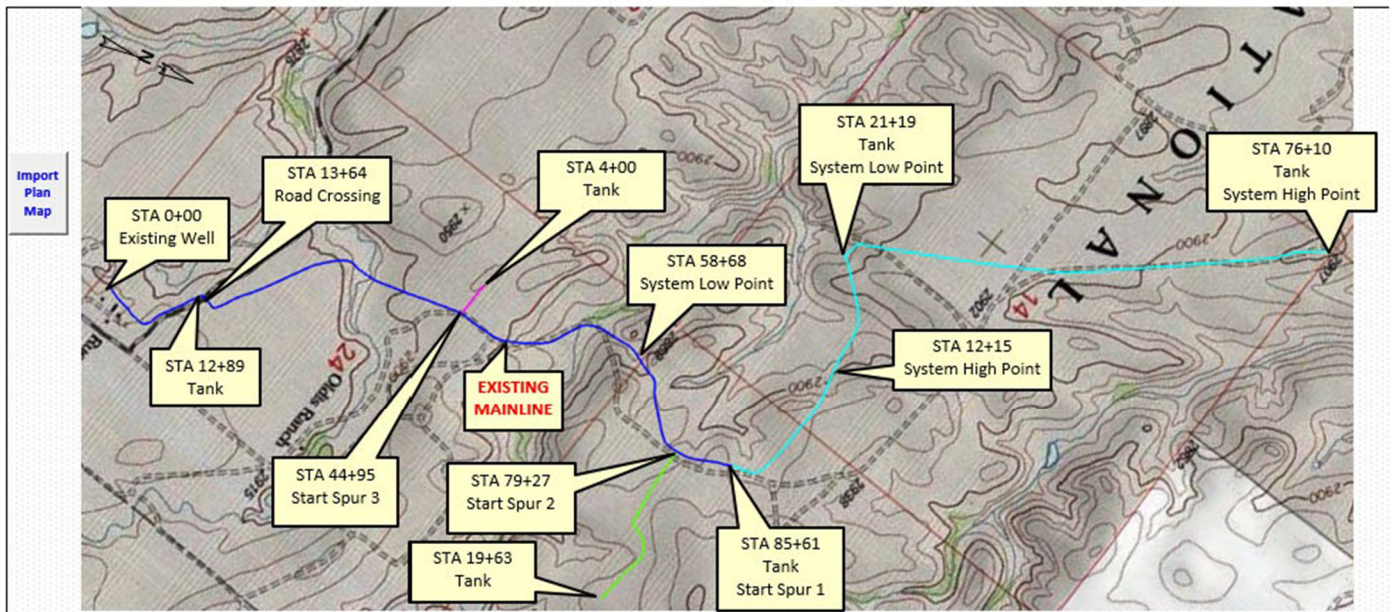


c. Select a “Callout” shape and insert onto the sheet.

Step 3. Type in the text of the stationing and move to the appropriate location. Edit size and position of callout as necessary. \*Note: The callout identification line can be moved independently of the text box. Also, the north arrow located on the sheet can be rotated as necessary



Step 4. Repeat this process to add stationing data at varying points of interest. \*Note: Shape color and size of the callouts can be changed by editing the properties of the shape. Likewise, the text size and color can also be changed.



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