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

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. The final construction package will include a coversheet, pipeline profiles, 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.

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:
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/nd/technical/engineering/?cid=nrcseprd366085

Resource Inventory Data:

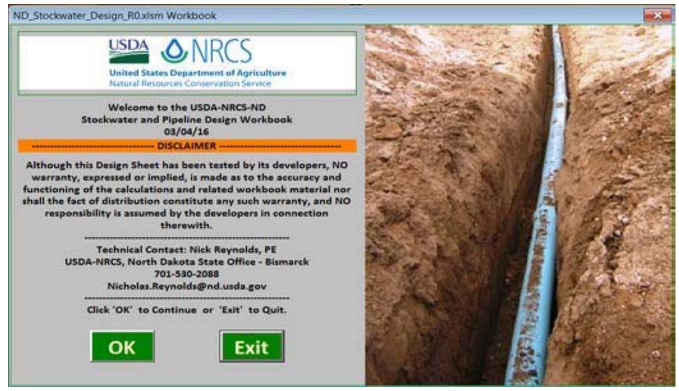
- Producer's name, location, project or practices to be planned
- Type and # of livestock or animals
- Grazing or stocking dates
- Type of grazing or stocking system including travel distance to water
- Source of water supply for planned system; including source characteristics such as water surface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

Pipeline Data:

- Pipeline layout
- Survey data of planned pipeline route
- Existing pipeline type, size, and route; if applicable

Section 2 – Workbook Information and Initial Setup

2.1 – Opening the Workbook

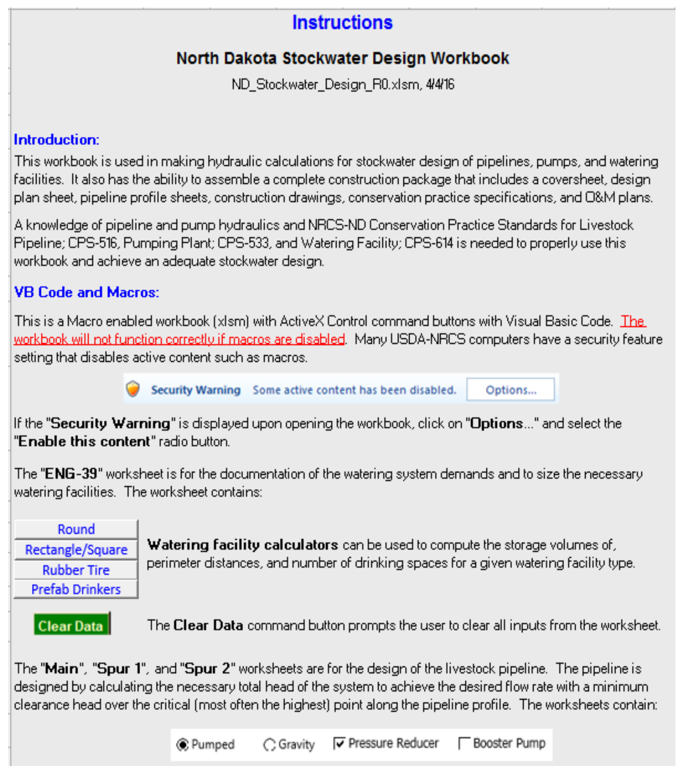


a) Open the spreadsheet named:
ND_Stockwater_Design_V3.0.xlsm
   i. The number after the V in the workbook name reflects what version of the workbook is being used. R0 was the initial version.

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: 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 (Red Triangles). If that doesn't answer it, refer back to the Instructions tab.

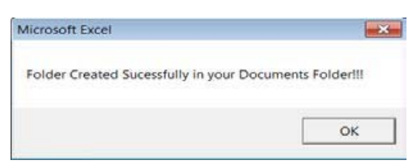
If you have questions or issues with the functions of the workbook, the following person may be contacted for user support:
Nick Reynolds
Nicholas.Reynolds@nd.usda.gov
Bismarck SO, North Dakota
Office 701-530-2088
Cell: 701-426-5753

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

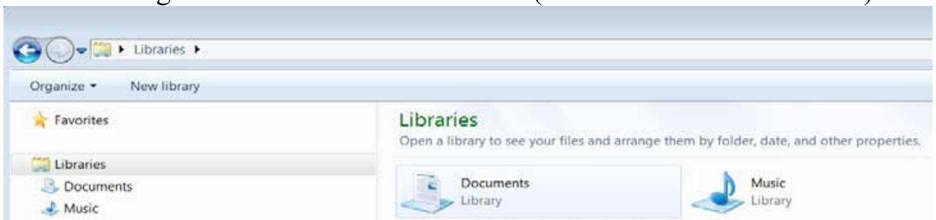
2.3 – Workbook Setup

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.**

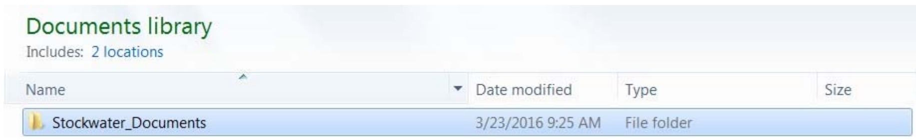
a) Create a save folder in the file save location
   i. Click on the **Make Save Folder** button



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 Libraries → Documents (Non-NRCS: Location = C:\)



- Folder should show to have been created

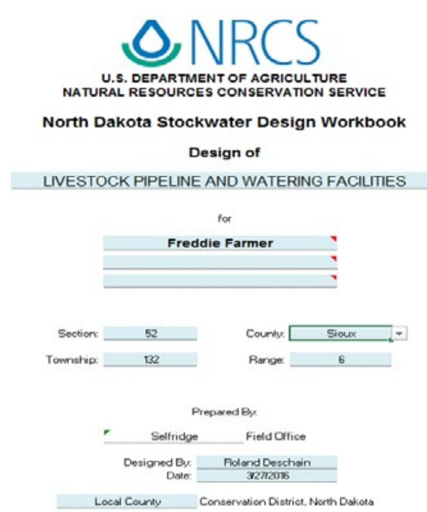


b) Download all the stockwater documents from the ND NRCS Engineering website. The documents include ND NRCS Practice Specifications and Operation & Maintenance (O&M) Plans for all the stockwater practices and the ND NRCS standard drawings for practice installation. In addition, a zip file is downloaded that includes a set of county highlighted maps for North Dakota for use on the design package Coversheet. It is important that an internet connection is available or the download will not work correctly. A check has been set up to determine internet connectivity. **The download of documents need only be done upon initial setup and as updates are issued. A blank version can be saved and used as a template for future designs. 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. Click on the **Workbook Setup** button
- Be patient; the download may take several minutes to execute
- A message will appear if no internet connection is found
  - Clicking **OK** will abort the document download
- 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**

ii. A list is displayed of the ZIP files downloaded to the NRCS_Stockwater_Documents folder

2.4 – Title Page

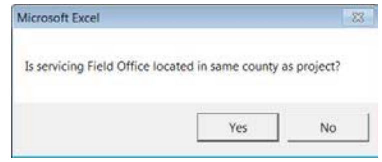


The Title Page tab is an informational page to record who, what, when, and where information relevant to the design. This information is used to populate other cells throughout the workbook. The information copied will be locked on subsequent tabs and would need to be changed on the Title Page tab if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

a) Select from the drop down menu which of the following system components are to be designed:
   i. Watering Facilities
   ii. Livestock Pipeline
   iii. Livestock Pipeline and Watering Facilities
   iv. Pump, Pipeline, and Watering Facilities

b) Enter information for the producer/landowner
   i. Name of contract participant
   ii. Additional information could include address, contact info, executor of entity/estate, etc.

c) Enter 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.

d) 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.
   ii. Date
      - This is the date of when the design was completed. The entered date is transferred to the rest of the design pages and drawings.

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.

United States Department of Agriculture
Natural Resources Conservation Service
Clear Data
ND_Stockwater_Design_R0.xlsm
Version 04-4-16
North Dakota

WATERING SYSTEM RESOURCE INVENTORY and WATERING FACILITY DESIGN WORKSHEET
ND-ENG-39

Producer:	Freddie Farmer	Field Office:	McClusky
Contract No.:		CIN(s):	
Location:	Section 52 Township 132 Range 6	Field(s) No.:	
Designed by:	Roland Deschain	Date:	3/27/2016
Checked by:		Date:	

a) Enter the Contract Number of the NRCS conservation contract

b) Enter the Contract Item Number ($CIN_{(S)}$) of items being designed and contracted

c) Enter the Field/Pasture Number associated with each CIN within the contract

d) Checked by:
   i. To be completed by NRCS personnel with the experience in the type of design. The checker shall be someone other than the designer.

e) 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.

Planned Watering System Description:

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 4 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.	
					Total: =	**5,000**	**gals.**	**13**

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.

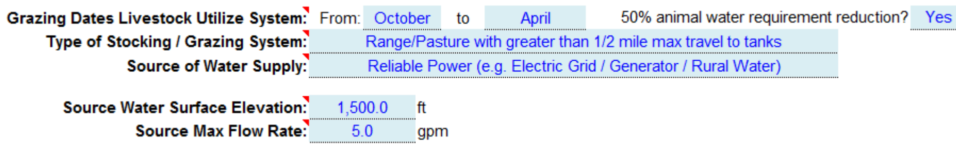
b) Enter the number of livestock or wildlife for each type selected
   i. If multiple herds or pastures are to be managed throughout the year, use the maximum number of animals that will utilize the system at one time.

c) 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) 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 valve used for sizing of the watering system.

e) 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.



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.
   ii. If the selected grazing dates are to be within October through April then Select **YES** from the drop down menu to use the reduced values.

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

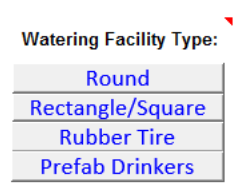
h) Choose from the drop down menu one of the following types of water sources that provides water to the system. The choice determines the required storage needed within the watering system.
   i. Reliable Power (e.g. Electric Grid / Generator / Rural Water)
   ii. Solar / Wind Power

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
      - 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.

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.

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

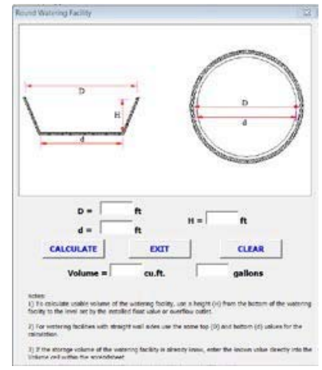
Calculators are included within the **ENG-39** worksheet to aid in the sizing of several different types of watering facilities. These types include Round, Rectangle/Square, Rubber Tire, and Prefab Drinkers. For the Round, Rectangle/Square, and Rubber Tire facilities the calculators can be used to compute 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.



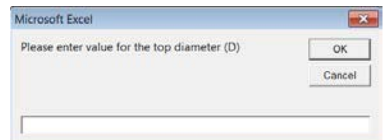
a) Click on the desired watering facility type to open the calculator

b) Enter each dimension or value, as shown on the figure, into the appropriate boxes

i. 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	x	1	=	254	gals.	16
Rectangle/Square	:		ft		gals	x	0	=	0	gals.	
Rubber Tire	:		ft		gals	x	0	=	0	gals.	
Prefab Drinkers	:	Min. Drinking Spaces:		# of Spaces per Waterer:				x		waters	
				Total Watering Facility Volume (WFV) =					254	gals.	16

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.

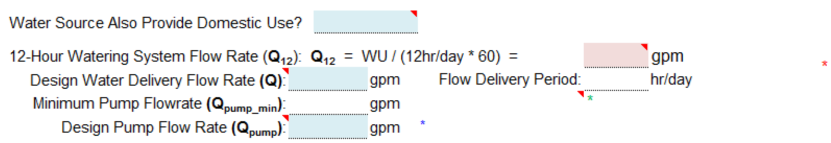
      * Additional space is required for drinking access! Increase tank perimeter or provide more tanks.

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 2gpm 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.



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 ($\mathbf{Q_{12}}$):
   i. $\mathbf{Q_{12}}$ 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 then $\mathbf{Q_{12}}$, 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 (ASmin) for storage needed.
   iv. For systems suppling 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 suppling 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 ($\mathbf{Q_{pump\_min}}$):
   i. $\mathbf{Q_{pump\_min}}$ is determined from the larger of the $\mathbf{Q_{min}}$ 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:

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 x WU - Inflow = 1 x 5,500 - 2,880 = **2,620** gals.

Required Additional Storage (**AS_{min}**): AS = RS-WFV = **2,366** gals. *

Design (**AS**) = 2,400 gals.

p) Required Days of Storage in Pasture (**DS_{min}**):

   i. **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

   i. 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**):

   i. **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}**):

   i. **AS_{min}** is the difference between the required storage in the pasture (**RS**) and the total watering facility volume (**WFV**).

   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**.

t) 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, design a storage tank, or increase system flow rate.

   ii. 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!

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

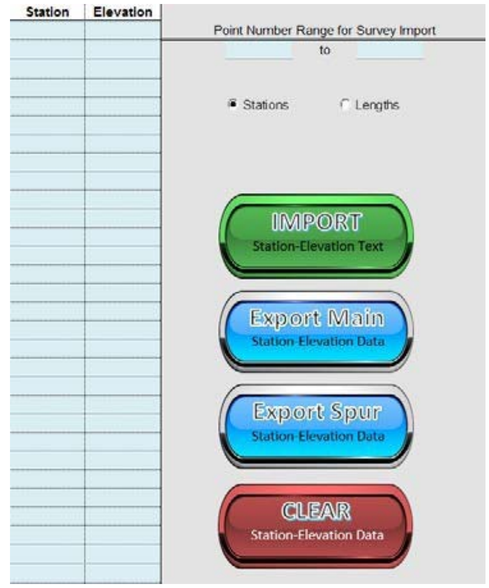
a) Enter the following information for any existing water sources available to the livestock/wildlife in the area to be serviced by the new watering system:
   i. Field Number where the existing water source is located
   ii. Type of Existing Water Source; i.e. pond, creek, wetland
   iii. Dependability/Quality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

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 to 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.

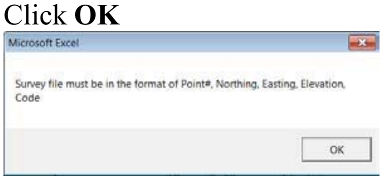
4.2 – File Import

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.

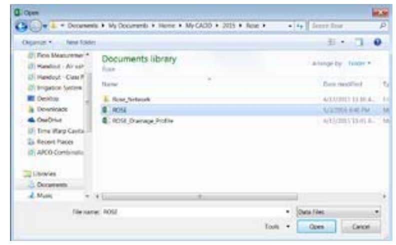
a) Enter the point range for the points to be exported to the pipeline design tabs
   i. If the range is left blank then the entire survey file is selected for export.

Point Number Range for Survey Import		
11	to	66

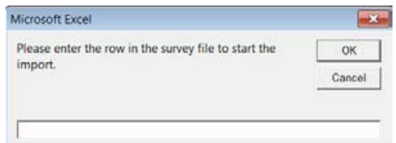
b) Click the **Import** button
   i. A dialog box appears reminding of the required file format of PNEZD. Click **OK**



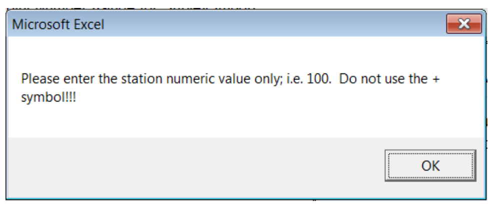
ii. A Windows Explorer opens
  - Navigate to the folder location of the desired survey file to import
  - Select the survey file to import
    - Click **Open**



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

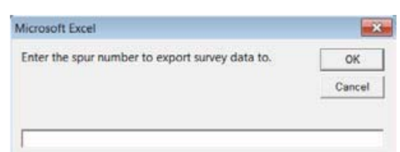
The imported data can be exported to the desired pipeline section for design. There are two Export features available; one for the Main Line and one for the Spur Lines.

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)
    - Note: The Spur tab(s) remain hidden until spur data is exported.

4.4 – 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

Section 5 – Livestock Pipeline Design

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

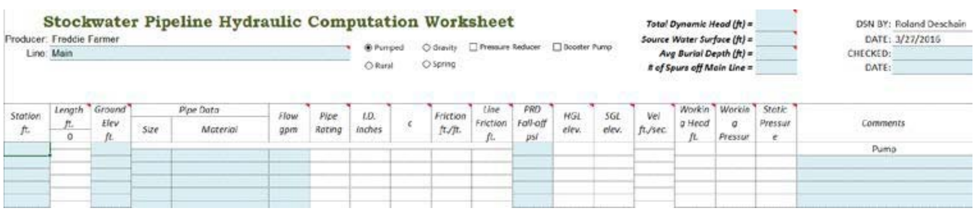
There are several types of livestock pipeline systems that can be modeled in the ND_Stockwater_Design workbook.

- 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 5 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.

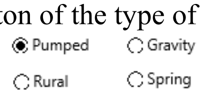
5.3 – Pipeline Design; Main Line

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**.



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



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.

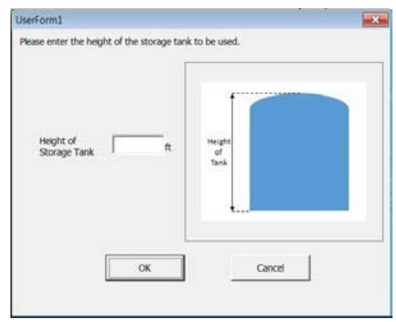
g) Enter the desired flow rate for the pipeline design run
   i. The value is typically the Design Water Delivery Flow Rate (**Q**) determined in the ENG-39.
      - See **Section 3.3 l)**

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.

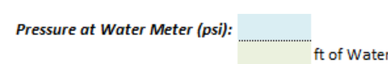
i) Comments can be entered for each station of the pipeline starting in Cell S12. These can include design specific requirements for a particular station or the location of special features.

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



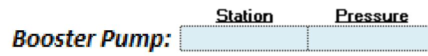
      - Enter the converted value into the **Head at Water Meter (ft)** in Cell R1
   iv. Spring
      - Enter the **Head at Spring (ft)** in Cell R1
        - Normally this value is 0 and is representative of the water level in the spring box being at natural ground elevation.
        - A negative value represents 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.

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

   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**

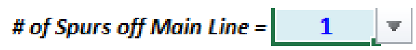


- Cells appear to enter data for the **Booster Pump**
  - Enter the value of the station where the booster pump will be installed
  - Enter the hydraulic pressure rating of the booster in units of PSI
  - The system working pressure is increased to the value of the pressure added by the booster starting from that location.

5.4 – Pipeline Design; Spur Lines

The design workbook can model up to 5 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.
   - 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)

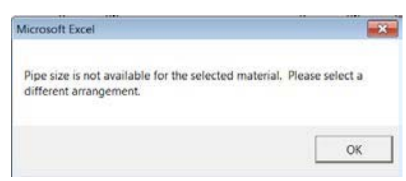
i. These options are only available when the Main line is modeled as Pumped
ii. Pumped – Spur is modeled as a continuous pumped system from the main line continuing through the spur line.
iii. Pumped/Gravity – The main line is a pumped system. The spur is modeled as a gravity line from a tank or storage 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.

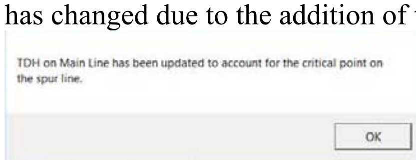
i) Enter the desired flow rate for the pipeline design run
i. The value is typically the Design Water Delivery Flow Rate (**Q**) determined in the ENG-39 worksheet.
   - See **Section 3.3 l)**

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.

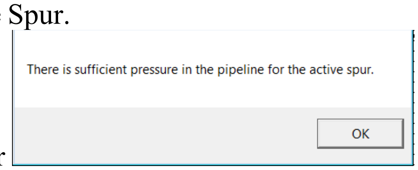
k) Comments can be entered for each station of the pipeline starting in Cell S12. These can include design specific requirements for a particular station or the location of special features.

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.

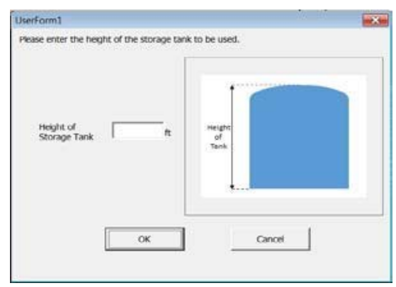


or

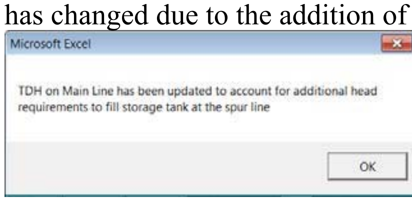


         - The HGL Elevation in Cell R1 is updated as necessary to show the final HGL elevation of the spur tie-in station.

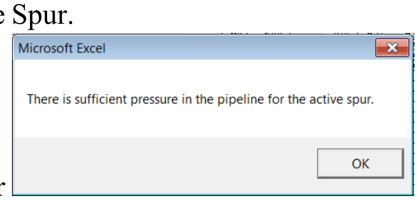
   ii. Pumped/Gravity
      - Click the **Tank Elev** button
         - If the height of the tank has not been manually entered, a box appears asking to "Please enter the height of the storage tank to be used."
         - This is the maximum height of water in the storage tank at the float or overflow.
         - 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.



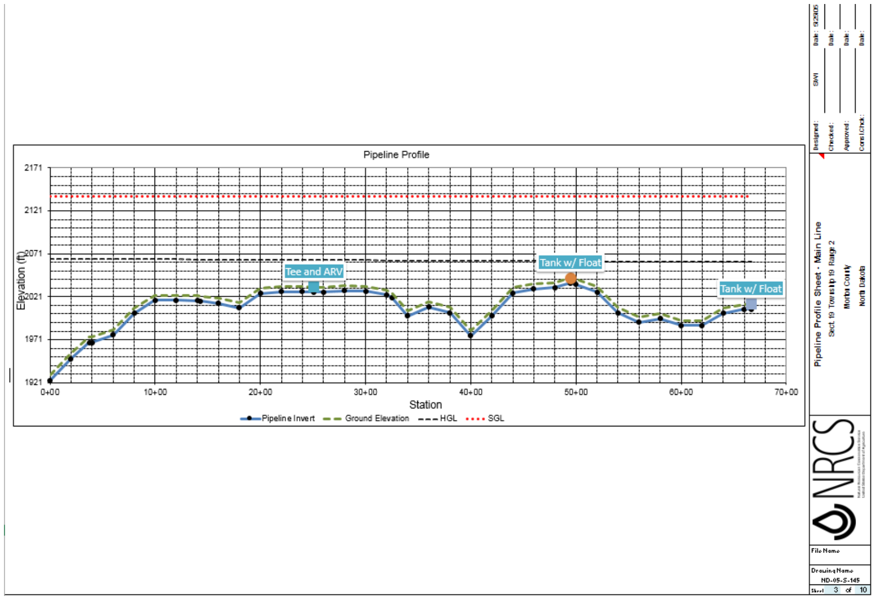
or



   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.

5.5 – Pipeline Profiles

A profile of ground elevations along a pipeline route can be a valuable tool for visualizing how the changes in elevation along the line affect the system's operating conditions and pressures. Plotting a ground line profile, the associated hydraulic grade line (HGL), and the static head can be very beneficial for designers in understanding the results of the calculated pipeline hydraulics. A detailed profile map can pinpoint which points along the pipeline will be controlling factors (control points). The plotted HGL can clearly show if there are any potential operating pressure issues.



a) A Profile tab is available for both the mainline as well as any spur line
   i. The profile for the spurs remain hidden unless a spur is designed.

b) Click on a Profile tab
   i. A profile of the pipeline is automatically plotted from the survey data entered on the appropriate pipeline design tab; i.e. Main, Spur 1, Spur 2, ….
      - See **Section 5.3** or **Section 5.4** to make any edits; if needed
   ii. The HGL and static pressures are automatically plotted on the profile graph.
      - If the HGL and static pressure lines do not appear to be plotted correctly, see **Section 5.3** or **Section 5.4** to ensure that the pipeline hydraulics have been run as attended.

c) Enter Station and Item information in the Appurtenances table to add labels to the plotted pipeline profile for any appurtenances to be installed along the line. **Appurtenances are critical to pipeline design and can control system operation to a larger extent than the selected pump or pipeline material.**
   i. Select the desired station from the dropdown list where the appurtenance is to be located.
      - The corresponding elevation for the selected station is populated.
   ii. Enter the name of the appurtenance item for the selected station.
   iii. Click the **Add to Profile** button to add the entered items to the plotted pipeline profile.
      - An icon appears on the profile along with a label containing the name of the item.
   iv. Items entered in the table can be edited and updated on the profile by re-clicking the Add to Profile button.

Location of Appurtenances and Profile of Main Line

Station	Elevatio	Item
25+10	2032.4	Tee and ARV
49+50	2043.1	Tank w/ Float
66+65	2012.5	Tank w/ Float

d) Repeat Step c) for each spur profile as applicable

Section 6 – Design of Pumping Plant and Pressure Systems

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.

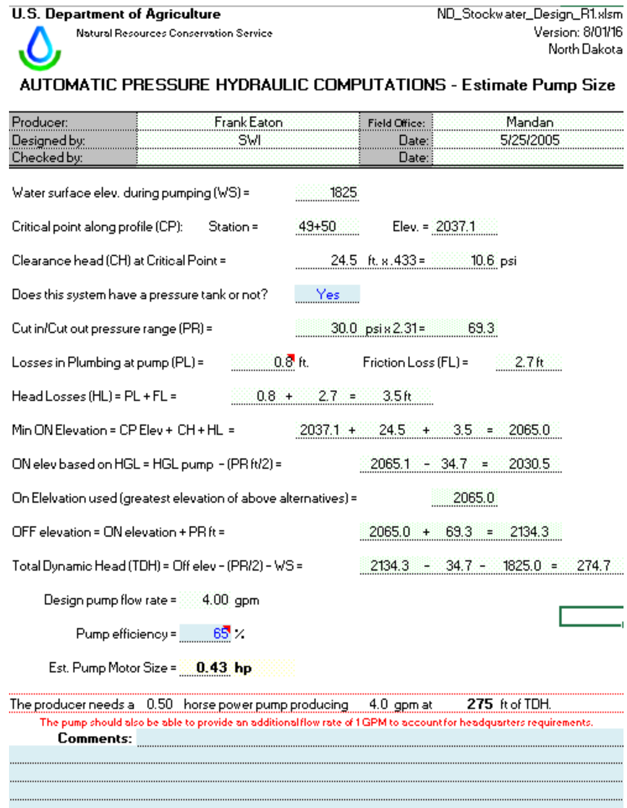
There are several considerations to keep in mind when sizing a pump:

- 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.

6.2 – Estimating Pump Size

The design workbook is set up to model either an automatic pressure system consisting of a pressure tank or a system controlled by a timer or float. The Pump tab determines the minimum TDH requirement of the pumping plant to operate the system. The majority of the Pump tab is automatically calculated and populated with data from the ENG-39 and pipeline design tabs.



U.S. Department of Agriculture
Natural Resources Conservation Service
ND_Stockwater_Design_R1.xlsm
Version: 8/01/16
North Dakota

AUTOMATIC PRESSURE HYDRAULIC COMPUTATIONS - Estimate Pump Size

Producer:	Frank Eaton	Field Office:	Mandan
Designed by:	SWI	Date:	5/25/2005
Checked by:		Date:	

Water surface elev. during pumping (WS) = 1825

Critical point along profile (CP): Station = 49+50 Elev. = 2037.1

Clearance head (CH) at Critical Point = 24.5 ft. x .433 = 10.6 psi

Does this system have a pressure tank or not? Yes

Cut in/Cut out pressure range (PR) = 30.0 psi x 2.31 = 69.3

Losses in Plumbing at pump (PL) = 0.8 ft. Friction Loss (FL) = 2.7 ft

Head Losses (HL) = PL + FL = 0.8 + 2.7 = 3.5 ft

Min ON Elevation = CP Elev + CH + HL = 2037.1 + 24.5 + 3.5 = 2065.0

ON elev based on HGL = HGL pump - (PR ft/2) = 2065.1 - 34.7 = 2030.5

On Elelvation used (greatest elevation of above alternatives) = 2065.0

OFF elevation = ON elevation + PR ft = 2065.0 + 69.3 = 2134.3

Total Dynamic Head (TDH) = Off elev - (PR/2) - WS = 2134.3 - 34.7 - 1825.0 = 274.7

Design pump flow rate = 4.00 gpm

Pump efficiency = 65 %

Est. Pump Motor Size = **0.43 hp**

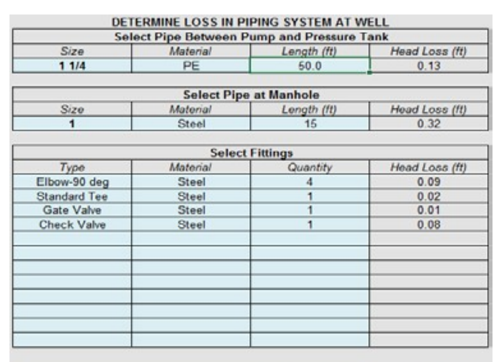
The producer needs a 0.50 horse power pump producing 4.0 gpm at **275** ft of TDH.

The pump should also be able to provide an additional flow rate of 1 GPM to account for headquarters requirements.

Comments:

a) Choose either **Yes** or **No** from the drop down menu in Cell F17 for "Does this system have a pressure tank or not?"
   i. A selection of **Yes** is for systems that include a pressure tank. Information and calculations for the on/off elevations of the pressure switches are then displayed.
   ii. A selection of **No** is for timer/float type systems. All on/off elevation data is hidden.

b) Review all populated and calculated values and make any necessary changes on either the ENG-39 or pipeline design tabs.
   i. Water surface elev. during pumping (WS):
      - Populates from the entry on the ENG-39 tab
   ii. Critical point along profile (CP):
      - Calculated as the station and elevation of the hydraulically most critical point along the pipeline.
   iii. Clearance head (CH) at critical point:
      - Calculated as the minimum elevation difference between the hydraulic grade line (HGL) and the control point.
   iv. Cut-in / Cut-out pressure range (PR):
      - Used only for pressure tank systems.
      - Set based on the total system operating pressure.
         - 20psi for operating pressures <80 psi
         - 30psi for operating pressures 80-120 psi
         - 40psi for operating pressures >120 psi
   v. Losses in plumbing at pump (PL):
      - Use chart to determine the friction losses in the piping system at the well. Default lengths and fittings are given but can be edited if plumbing is set up differently.



DETERMINE LOSS IN PIPING SYSTEM AT WELL

Select Pipe Between Pump and Pressure Tank

Size	Material	Length (ft)	Head Loss (ft)
1 1/4	PE	50.0	0.13

Select Pipe at Manhole

Size	Material	Length (ft)	Head Loss (ft)
1	Steel	15	0.32

Select Fittings

Type	Material	Quantity	Head Loss (ft)
Elbow-90 deg	Steel	4	0.09
Standard Tee	Steel	1	0.02
Gate Valve	Steel	1	0.01
Check Valve	Steel	1	0.08

Total Head Loss (ft): 0.66

   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 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 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 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.

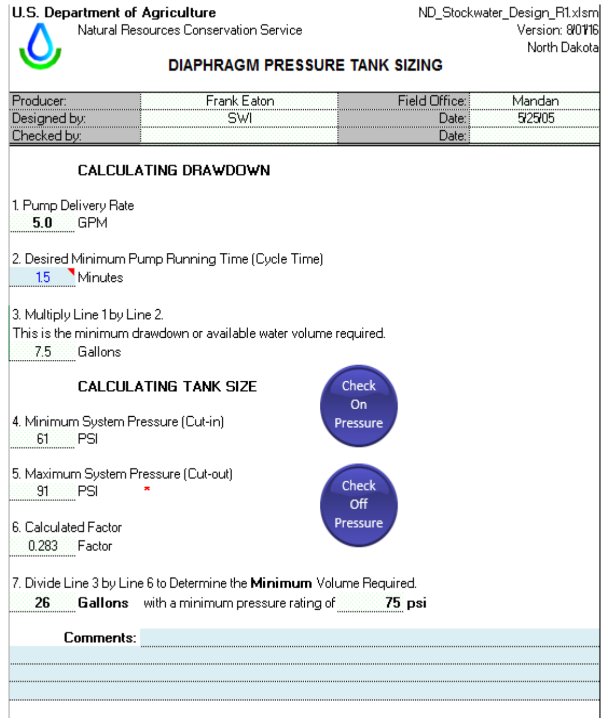
Operating a pressure tank higher than its rated pressure is very dangerous. A tank used beyond its rating could explode and cause death or serious injury to anyone near the tank. For this reason, **a pressure tank should never be used beyond its rated pressure.** Tanks not designed for water use; i.e. 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_{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



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 – ((Cut-in Pressure + 14.7) / (Cut-out Pressure + 14.7))

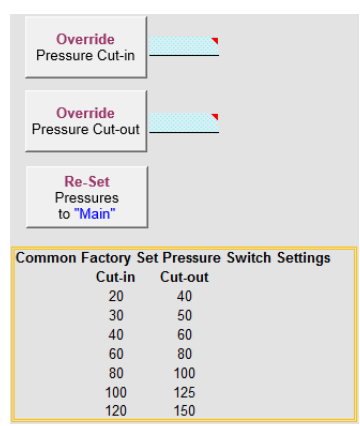
iv. Minimum Tank Volume and Pressure Rating
   - The total volume of the pressure tank is calculated by dividing the tank's water volume by the tank efficiency.
   - The minimum working pressure of the pressure tank is set based on the maximum system operating pressure.
     - All pressure tanks are 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.

Please Select Desired Pump ---->		○		○		◉		○	
		Goulds 7LS		Franklin 7		Goulds 7GS		Custom Pump or	
4 GPM		1/2 HP		1/2 HP		1/2 HP		Existing Water Source	
System		Pump Info #1		Pump Info #2		Pump Info #3		Custom Source Info	
GPM	TDH	GPM	TDH	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	

a) Review the calculated system curve data.

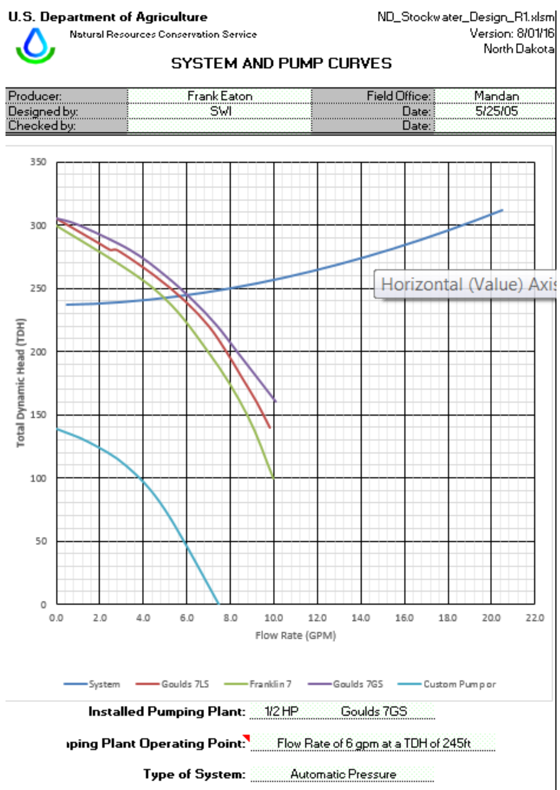
b) Select the installed pump or pump(s) to be analyzed from the drop down list. Skip to Section c) if pump is not shown in list.

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

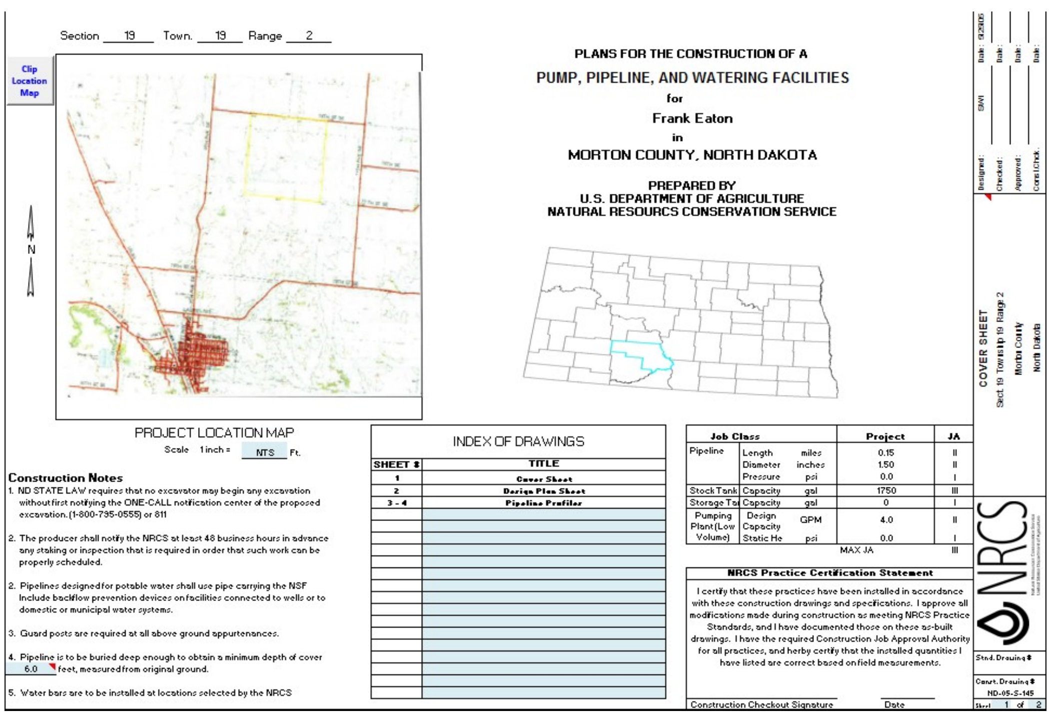


7.1 – *Construction Package Requirements*

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.

7.2 – 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.

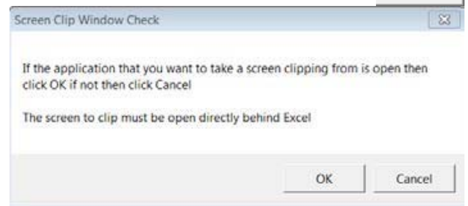


a) Verify the title information and the state county map on the coversheet
   i. Make any necessary changes on the Title Page tab of the workbook; see **Section 2.4 – *Title Page***.

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

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

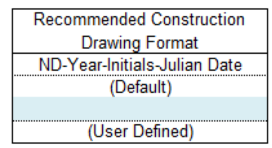
i. The EJAA table is automatically populated with the design values from the appropriate design tabs and the corresponding EJAA class value.

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

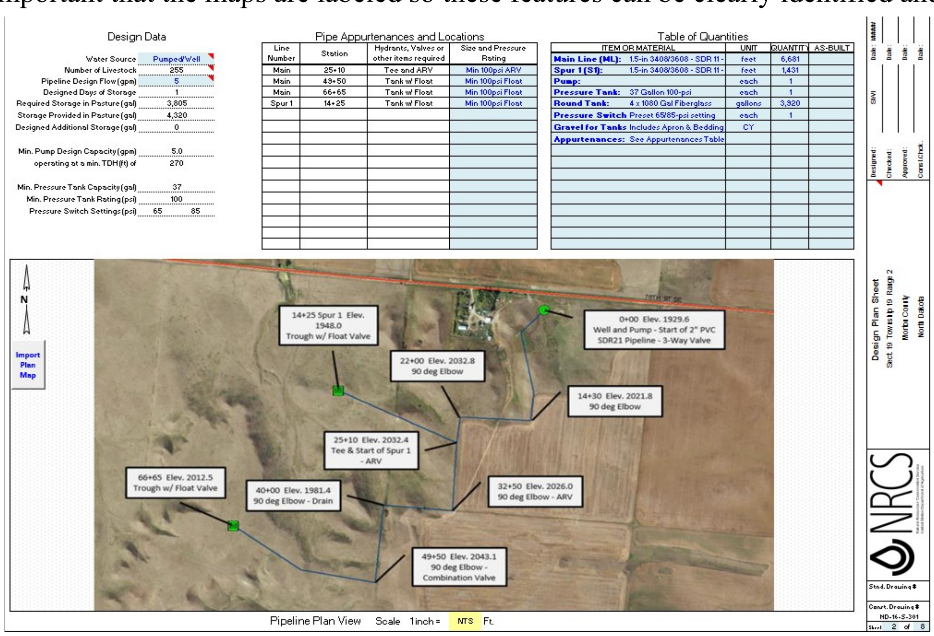
ii. This can be overridden with a user defined name in Cell AD55



7.3 – 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.



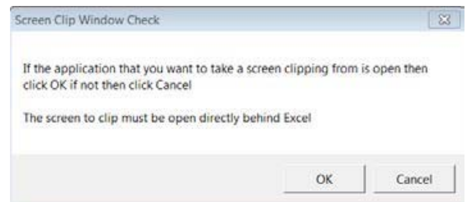
a) Review the summary of the design data for the practices planned
   i. Information will vary depending on what components of the watering system are being designed.
      - Pump and pressure tank data are not visible when they are not planned.
   ii. Make any necessary changes by returning to the appropriate workbook tab.

b) Enter a description of the Water Source in Cell E4

c) Enter the Pipeline Design Flow (gpm) of the system in Cell E6

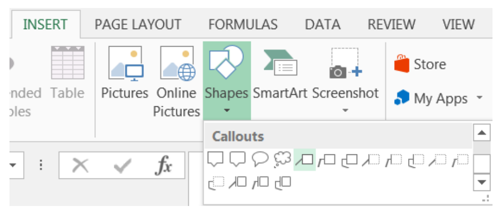
d) Import a project plan map

   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

e) 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.

f) 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***.

g) 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.

h) 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.

i) 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.

7.4 – ND-ENG-1; Construction Specifications Cover Sheet

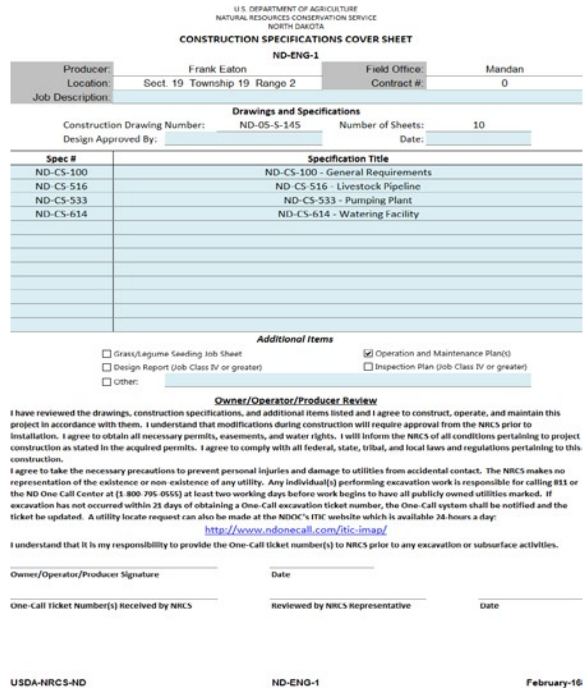
The ND-ENG-1 Construction Specification Cover Sheet provides an overview of what supporting documentation is contained within the design package. The ENG-1 also reviews and explains the procedure for obtaining and documenting the required utility safety One-Call ticket number.

a) Enter a brief Job Description summary of the planned stockwater system in Cell C8

b) 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.

c) 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.

d) 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.S. DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE
NORTH DAKOTA

CONSTRUCTION SPECIFICATIONS COVER SHEET

ND-ENG-1

Producer:	Frank Eaton	Field Office:	Mandan
Location:	Sect. 19 Township 19 Range 2	Contract #:	0
Job Description:			

Drawings and Specifications

Construction Drawing Number: ND-05-S-145 Number of Sheets: 10
Design Approved By: Date:

Spec #	Specification Title
ND-CS-100	ND-CS-100 - General Requirements
ND-CS-516	ND-CS-516 - Livestock Pipeline
ND-CS-533	ND-CS-533 - Pumping Plant
ND-CS-614	ND-CS-614 - Watering Facility

Additional Items

☐ Grass/Legume Seeding Job Sheet ☑ Operation and Maintenance Plan(s)
☐ Design Report (Job Class IV or greater) ☐ Inspection Plan (Job Class IV or greater)
☐ 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, and local laws and regulations pertaining to this construction.
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 number, the One-Call system shall be notified and the ticket be updated. A utility locate request can also be made at the NDOC's ITIC website which is available 24-hours a day:

http://www.ndonecall.com/itic-imap/

I understand that it is my responsibility to provide the One-Call ticket number(s) to NRCS prior to any excavation or subsurface activities.

Owner/Operator/Producer Signature Date

One-Call Ticket Number(s) Received by NRCS Reviewed by NRCS Representative Date

USDA-NRCS-ND ND-ENG-1 February-16

e) 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

f) Review the landowner utility One-Call information and ensure that all signatures and ticket numbers are obtained after print out of the construction package.

7.5 – Drawings and Documents

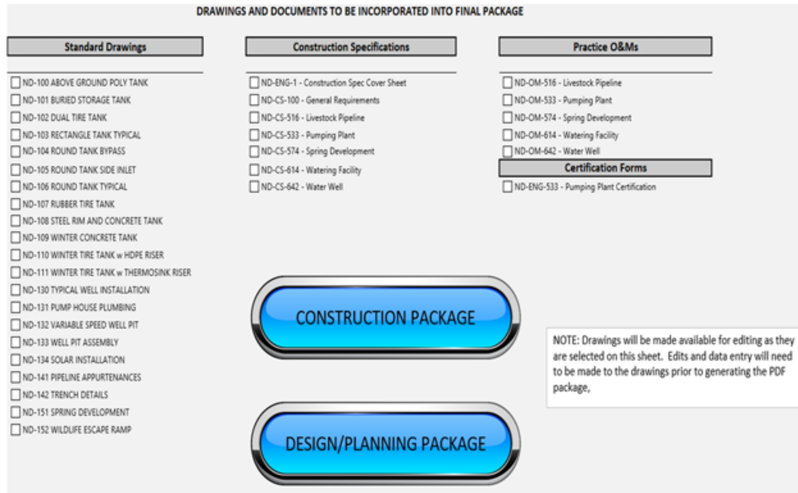
The creation of the construction package relys on the download of documents from the North Dakota NRCS Engineering Website. If not previously done, please refer to **Section 2.3 –*Workbook Setup*** to complete the document download.

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:



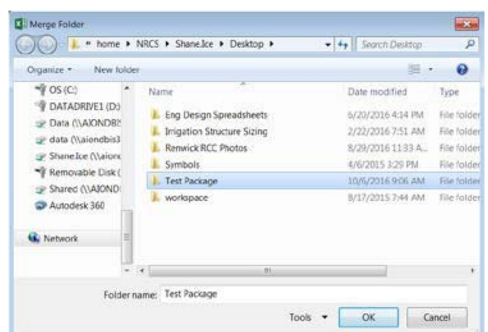
a) Select the appropriate engineering standard drawings to be included in the construction package
   i. As drawing sheets are selected, an associated tab will become visible from which the user can review the drawing and enter any appropriate design information in available text boxes.

b) Select the appropriate practice construction specifications to be included in the construction package

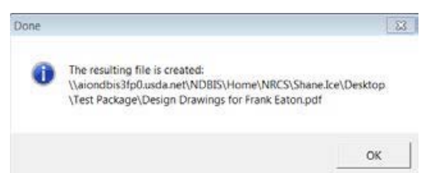
c) Select the appropriate practice operation and maintenance (O&M) plans to be included in the construction package

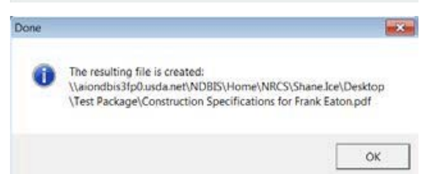
d) Select the appropriate engineering forms to be included in the construction package

e) Click the **Generate Construction Package** button
   i. 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.
   ii. Review the list of drawings and documents included in the generated package



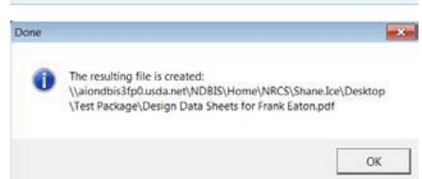
f) Click the **Generate Design/Planning Package** button
   i. A Windows Explorer box appears
      - Navigate to and choose a file folder to save the generated packages
        - Select the folder only; do not open the folder
      - Click **OK**
      - A message appears stating that the Design Data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





g) Open Windows Explorer and navigate to the folder where the packages have been saved

h) Review the content of each file generated
   i. Complete the Items of Construction Detail for all appropriate construction specifications with any additional information specific to the design.



Appendix 1 – *Pipeline Tables*

INSIDE DIAMETER FOR PIPE

	3408/3608 - SDR 7 - ODC	3408/3608 - SDR 7.3 - ODC	3408/3608 - SDR 9 - ODC	3408/3608 - SDR 11 - ODC	3408/3608 - SDR 13.5 - ODC	3408/3608 - SDR 15.5 - ODC	3408/3608 - SDR 17 - ODC
1	0.917	0.933	1.005	1.062			
1 1/4	1.157	1.178	1.269	1.340			
1 1/2	1.325	1.348	1.452	1.534			
2	1.656	1.685	1.816	1.917	2.002	2.050	2.079
2 1/2							
3	2.440	2.484	2.676	2.825	2.950	3.021	3.064
4	3.137	3.193	3.440	3.633	3.793	3.885	3.939
6	4.619	4.701	5.064	5.348	5.585	5.719	5.799

PRESSURE RATING FOR PIPE

	3408/3608 - SDR 7 - ODC	3408/3608 - SDR 7.3 - ODC	3408/3608 - SDR 9 - ODC	3408/3608 - SDR 11 - ODC	3408/3608 - SDR 13.5 - ODC	3408/3608 - SDR 15.5 - ODC	3408/3608 - SDR 17 - ODC
1	267	254	200	160	128	110	100
1 1/4	267	254	200	160	128	110	100
1 1/2	267	254	200	160	128	110	100
2	267	254	200	160	128	110	100
2 1/2							
3	267	254	200	160	128	110	100
4	267	254	200	160	128	110	100
6	267	254	200	160	128	110	100

	4710 - SDR 7 - ODC	4710 - SDR 9 - ODC	4710 - SDR 11 - ODC	4710 - SDR 13.5 - ODC	4710 - SDR 17 - ODC	4710 - SDR 19 - ODC	4710 - SDR 21 - ODC
1	0.916	1.005	1.061	1.109			
1 1/4	1.158	1.270	1.340	1.399			
1 1/2	1.325	1.453	1.533	1.601			
2	1.656	1.815	1.917	2.002	2.078		
2 1/2							
3	2.440	2.675	2.826	2.951	3.063	3.110	3.146
4	3.137	3.440	3.633	3.794	3.938	3.998	4.046
6	4.619	5.065	5.349	5.584	5.798	5.885	5.957

	4710 - SDR 7 - ODC	4710 - SDR 9 - ODC	4710 - SDR 11 - ODC	4710 - SDR 13.5 - ODC	4710 - SDR 17 - ODC	4710 - SDR 19 - ODC	4710 - SDR 21 - ODC
1	333	250	200	160			
1 1/4	333	250	200	160			
1 1/2	333	250	200	160			
2	333	250	200	160	125		
2 1/2							
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 SDR 13.5	1120 - PVC SDR 17	1120 - PVC SDR 21	1120 - PVC SDR 26	1120 - PVC SCH 40	1120 - PVC SCH 80
1	1.121	1.161	1.189	1.195	1.049	0.957
1 1/4	1.414	1.464	1.502	1.532	1.380	1.278
1 1/2	1.618	1.676	1.720	1.754	1.610	1.500
2	2.023	2.095	2.149	2.193	2.067	1.939
2 1/2	2.449	2.537	2.601	2.655	2.469	2.323
3	2.982	3.088	3.166	3.230	3.068	2.900
4	3.834	3.972	4.072	4.154	4.026	3.826
6	5.643	5.845	5.993	6.115	6.065	5.761

	1120 - PVC SDR 13.5	1120 - PVC SDR 17	1120 - PVC SDR 21	1120 - PVC SDR 26	1120 - PVC SCH 40	1120 - PVC SCH 80
1	315	250	200	160	450	630
1 1/4	315	250	200	160	368	520
1 1/2	315	250	200	160	330	470
2	315	250	200	160	277	404
2 1/2	315	250	200	160	303	424
3	315	250	200	160	263	375
4	315	250	200	160	222	323
6	315	250	200	160	176	279

END OF FILE