Nutrient Tracking Tool (NTT)
User Manual
Version 23-10

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NTT Disclaimer

Although NTT has been tested by its developers, NO warranty, expressed or implied, is made as to the validity of the results and functioning of the program and related program material, nor shall the fact of distribution constitute any such warranty, and NO responsibility is assumed by the developers in connection therewith. The user assumes all risks and responsibilities for the use and application of NTT and interpretation of the results generated from the tool. The authors and their affiliated institution, TIAER, and any other U.S. Government agencies will NOT be liable to NTT users for any damage, including lost profits, lost savings, lost time, actions by regulatory agencies, or any other direct or indirect incidental or consequential damages occurring from the use of or inability to use NTT, its databases, its results, or its documentation for any purpose.

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Glossary

AOI	Areas of Interest
APEX	Agricultural Policy Environmental eXtender
AU	Animal Units
BASIC NTT	Basic version of Nutrient Tracking Tool
CSV	Comma-separated values
EPIC	Environmental Policy Integrated Climate
ESRI	Environmental Systems Research Institute
CSV	Comma-separated values
EPIC	Environmental Policy Integrated Climate
ESRI	Environmental Systems Research Institute
FEM	Farm Economic Model
FR	Field Routing
FS	Field Strip
GHz	Gigahertz
NASS	National Agriculture Statistics Service
NTT	Nutrient Tracking Tool
NTT-RE	Nutrient Tracking Tool – Research and Educational Institutes
PDF	Portable Document Format
PEC	Erosion Control Practice
PRISM	Parameter-Elevation Regressions on Independent Slopes Model
RAM	Random Access Memory
SF	Stream Fencing
SSURGO	Soil Survey Geographic Database
TIAER	Texas Institute for Applied Environmental Research
USDA	United States Department of Agriculture
USDA-NRCS	United States Department of Agriculture – Natural Resources Conservation Services
WASCOB	Water and Sediment Control Basin

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Nutrient Tracking Tool (NTT) Overview

The Nutrient Tracking Tool (NTT) was designed and developed by the Texas Institute for Applied Environmental Research (TIAER) at Tarleton State University with funding from United States Department of Agriculture (USDA) Office of Environmental Markets, USDA Natural Resource Conservation Service (NRCS) Conservation Innovation Grants program, and various state agencies.

NTT is a web-based program that evaluates the environmental (e.g., nutrient and sediment losses) and economic (e.g., cost and benefit) impacts of agricultural and forestry management practices at the farm and small watershed scale.

Using NTT, agricultural producers and land managers can define a diverse combination of land management practices and generate a report showing expected nutrient loss differences between their current practices and various other types of land management practices. NTT allows users to identify the most cost-effective management decisions to reduce nutrient losses and optimize their crop production in simulated fields.

NTT calculates and compares expected flow, nitrogen, phosphorus, sediment losses, and crop yield associated with different management practices using the Agricultural Policy Environmental eXtender (APEX) model (Williams et al., 2000). NTT also evaluates the costs and benefits associated with various management practices using the Farm Economic Model (FEM). For detailed information on FEM, refer to the NTT FEM User's Manual in the last section of this document. The FEM technical documentation is also available on the "NTT Documentation" page at the bottom of the home page. Economic and environmental models in NTT are simulated for 35 years and the results are presented as annual and monthly averages.

Data requirements for running NTT include soil information obtained from USDA-NRCS Soil Survey Geographic Database (SSURGO), climate data from Parameter-Elevation Regressions on Independent Slopes Model (PRISM) data, and detailed descriptions of crop management practices from local management practices. NTT currently provides all required data for all regions of mainland U.S.

NTT has been parameterized for all major crops in the mainland United States and Puerto Rico. To obtain a general parameterization for each state/region, a series of NTT runs simulating common crop rotations, soils, and weather patterns for the region are completed and the results are compared with expected crop yield and nutrient and sediment loss values obtained from USDA's National Agriculture Statistics Service (NASS, 2017) and any local data. During the second phase of parametrization process, the field-scale measured data from various sources (e.g., local measured studies and collaborators) are used to finalize the regional APEX parameters. Results of state-level and site-level parameterization can be found on the "Validations" page linked from the bottom of the NTT home screen.

Two versions of the new NTT program are available:

1. The BASIC NTT version is user-friendly and allows users to estimate N, P and sediment from crop and pasture lands.
2. The Nutrient Tracking Tool Research and Education (NTT-RE) version was developed for researchers and educational institutes for teaching and training purposes. NTT-RE includes additional functions that allow users to view and edit soil layers, view crop water and nutrient stresses, and modify the APEX parameters file for calibration and validation purposes. Farmers and ranchers conducting on-farm research may also be interested in this version.

The data sources and APEX simulations in both versions are identical. For more information regarding NTT, please refer to Saleh et al. (2011 and 2015).

About APEX

NTT uses the APEX, a biophysical simulation model, version 0806, to process user supplied information (APEX; Williams et al., 2000). Below are characteristics of the APEX model.

- The APEX model was developed to extend the Environmental Policy Integrated Climate (EPIC) model capabilities to whole farms and small watersheds (Williams et al., 2000) The individual field simulation components of EPIC were used for APEX development.
- In addition to the EPIC functions, APEX has components for routing water, sediment, nutrients, and pesticides across complex landscapes and channel systems to the watershed outlet.
- Recently, the carbon fate and transport function of the CENTURY model was incorporated in the latest version of APEX (version 2110). This allows APEX to simulate carbon dynamics in soil-plant system.
- APEX also has groundwater and reservoir components. A field or watershed can be subdivided as much as necessary to assure that each subarea is relatively homogeneous in terms of soil, land use, management, etc.
- The routing mechanisms provide for evaluation of interactions between subareas involving surface runoff, return flow, sediment deposition and degradation, nutrient transport, and groundwater flow.
- Water quality in terms of nitrogen (ammonium, nitrate, and organic), phosphorus (soluble and adsorbed/mineral and organic), and pesticide concentrations may be estimated for each subarea and at the watershed outlet.
- Commercial fertilizers and/or manure may be applied at any rate and depth on specified dates or automatically.

System Requirements

Minimal Requirements

1. Windows: X86 or X64 1.6 GHz or higher processor with 512-MB of RAM
2. Macintosh (Intel-based): Intel Core Duo 1.86 GHz or higher processor with 512 MB of RAM

Supported Web Browsers

The NTT has been tested on the following browsers:

Apple Macintosh OS 10.5.7+ (Intel-based):

1. Firefox 12+
2. Safari 4+
3. Chrome 12+

Microsoft Windows 10 Desktop:

1. Microsoft Edge 110+
2. Firefox 110+
3. Chrome 111+

Microsoft Windows 8.1 Desktop:

4. Internet Explorer 11
5. Firefox 12+
6. Chrome 12+

Microsoft Windows 8 Desktop:

1. Internet Explorer 10
2. Firefox 12+
3. Chrome 12+

Microsoft Windows 7:

1. Internet Explorer 8 and 9
2. Firefox 12+
3. Chrome 12+

Microsoft Windows 7 SP1:

1. Internet Explorer 8, 9, 10, and 11

2. Firefox 12+
3. Chrome 12+

Microsoft Windows Server 2012

1. Internet Explorer 10
2. Firefox 12+
3. Chrome 12+

Microsoft Windows Server 2008 SP2:

1. Internet Explorer 7, 8, and 9
2. Firefox 12+
3. Chrome 12+

Microsoft Windows Server 2008 R2 SP1:

1. Internet Explorer 8, 9, and 11
2. Firefox 12+
3. Chrome 12+

Microsoft Windows Vista:

1. Internet Explorer 7, 8, and 9
2. Netscape 9.0
3. Firefox 12+
4. Chrome 12+

Microsoft Windows Server 2003/Windows XP:

1. Internet Explorer 7 and 8
2. Netscape 9.0
3. Firefox 12+
4. Chrome 12+

Display Resolution

The software has been tested and works correctly at resolutions as low as 800×600, but the lower the resolution, the more the user will have to scroll.

JavaScript

To run NTT, JavaScript is required. If JavaScript is disabled in your browser, the application simply will not work at all. Users will see an error message in this case.

Popup Blocker

By default, NTT opens some content in an external browser window, specifically:

- Links to other sites
- Help Screens

Pop-up blockers need to be configured to allow pop-ups to open these in an external browser window.

NTT Navigation Basics

The NTT was designed to be user friendly, with nine main pages. A pop-up window on the sign-in page provides users with a summarized introduction to the program. The left column of each program page tracks project development and facilitates navigation among completed pages.

NTT Projects Page

After creating an account in NTT and logging in, users are directed to the Projects page (Figure 1). The Projects pages displays all the projects that the user has previously created. On this page, users can create a new project, open a saved project, or upload a project stored on their local machine.
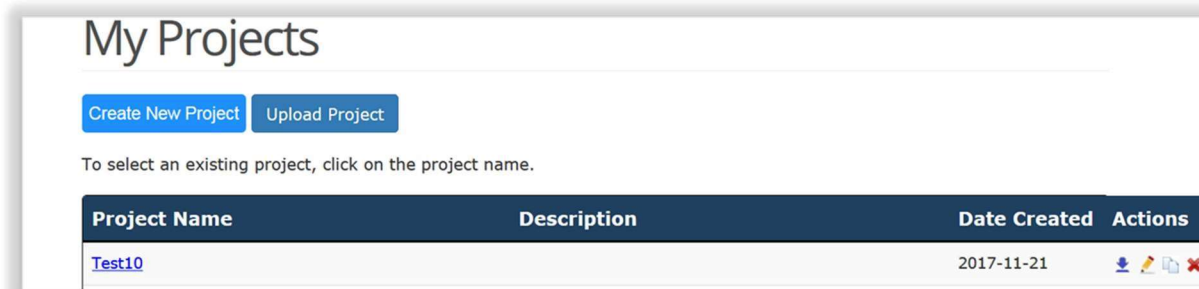

Figure 1: Project screen.

a) Create a New Project

Click the Create New Project button to create a new project (Figure 2). You will be asked for the project name and a project description (optional). After you have entered the information, click the Save button to save the information and continue.
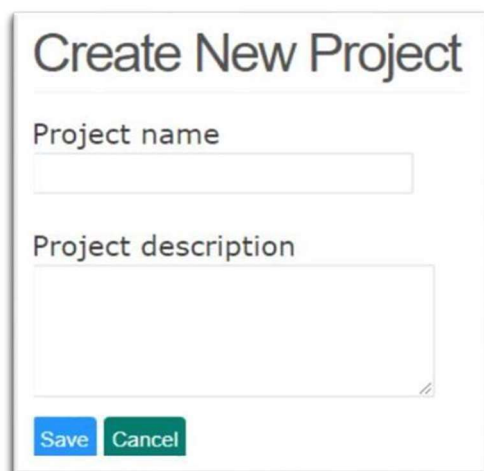

Figure 2: Create New Project screen.

b) Upload Project

Users may use the Upload Project button to retrieve an NTT Saved File containing information previously saved on their computer or flash drive.

Click Choose File and select Upload Project, then select Choose File and navigate to the saved file on your computer or flash drive. After you have selected the project, click the Upload Project button to upload the project and continue (Figure 3).
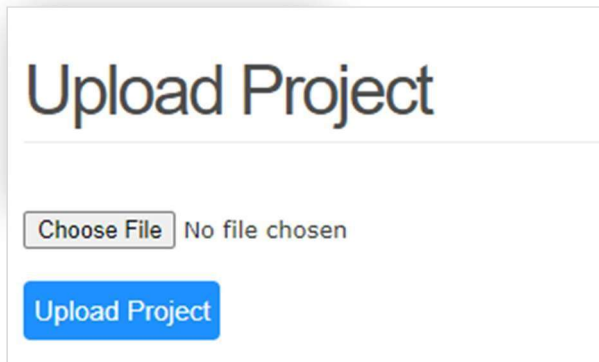
Figure 3: Upload Project screen.

c) Open Saved Project

To open a saved project, simply click on the project name to open the project and begin editing.

d) Download, delete, copy, and rename project

To download a project, click on ↓ icon, to delete click on ✖ icon, to duplicate use ⧉ icon, and to rename click the on ✎ icon.

NTT Location Page

After creating a new project, users will be asked to define the location of the project using the interactive Google map. The interactive map allows the user to define one or more areas of interest (AOI). The AOI should correspond with the fields within the project area. The map can ONLY be used for the mainland United States and Puerto Rico. If users would like to simulate using an area outside of the mainland United States, follow the instructions for User Input.

When defining the AOI, the underlying weather, soils, and slope information is automatically retrieved from the underlying spatial data within this program.
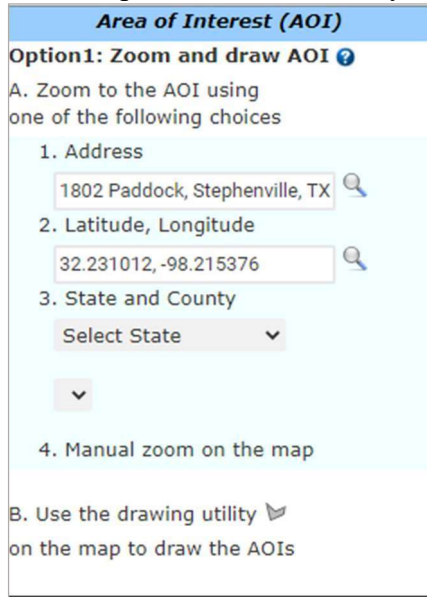
a) Mapping System

There are two ways to define AOI by: (a) manually drawing areas of interest using the zoom features and drawing tools on the interactive map, or (b) uploading shape files.

b) Zoom and Draw the AOI

If you do not already have a shapefile, you may draw your AOI using the zoom features and drawing tools on the interactive map. Users may draw multiple AOIs. AOIs should represent fields within the project area.

1. Zoom to your area of interest: A field is considered an AOI in NTT. There are several ways to zoom in to your AOI. You may enter an address, enter the latitude and longitude (using the correct format where latitude comes before longitude; north latitude is positive, east longitude is positive), select the state and county from the available pick lists, or manually zoom on the map using the zoom tool (Figure 4).

Figure 4: Location, Drawing AOI screen.

2. Draw your AOI: Once you have zoomed in on AOI, click the polygon button ⋈ at the top center of the map. Next, use your mouse and click to define the corners of your polygon as shown in Figure 5 below. After drawing the field, a pop-up box will appear where the user will enter the name of the AOI as shown below. Enter name of the field and click OK. As the user enters the name, it will replace the default name in the text box for the field as shown in Figure 6. For the remainder of the program, the field name entered will refer to the selected location. You may create multiple AOIs/fields for your project with separate names. Simply click on the polygon button again and create additional AOIs. Once the user clicks OK, the field location will be highlighted as shown in Figure 6.
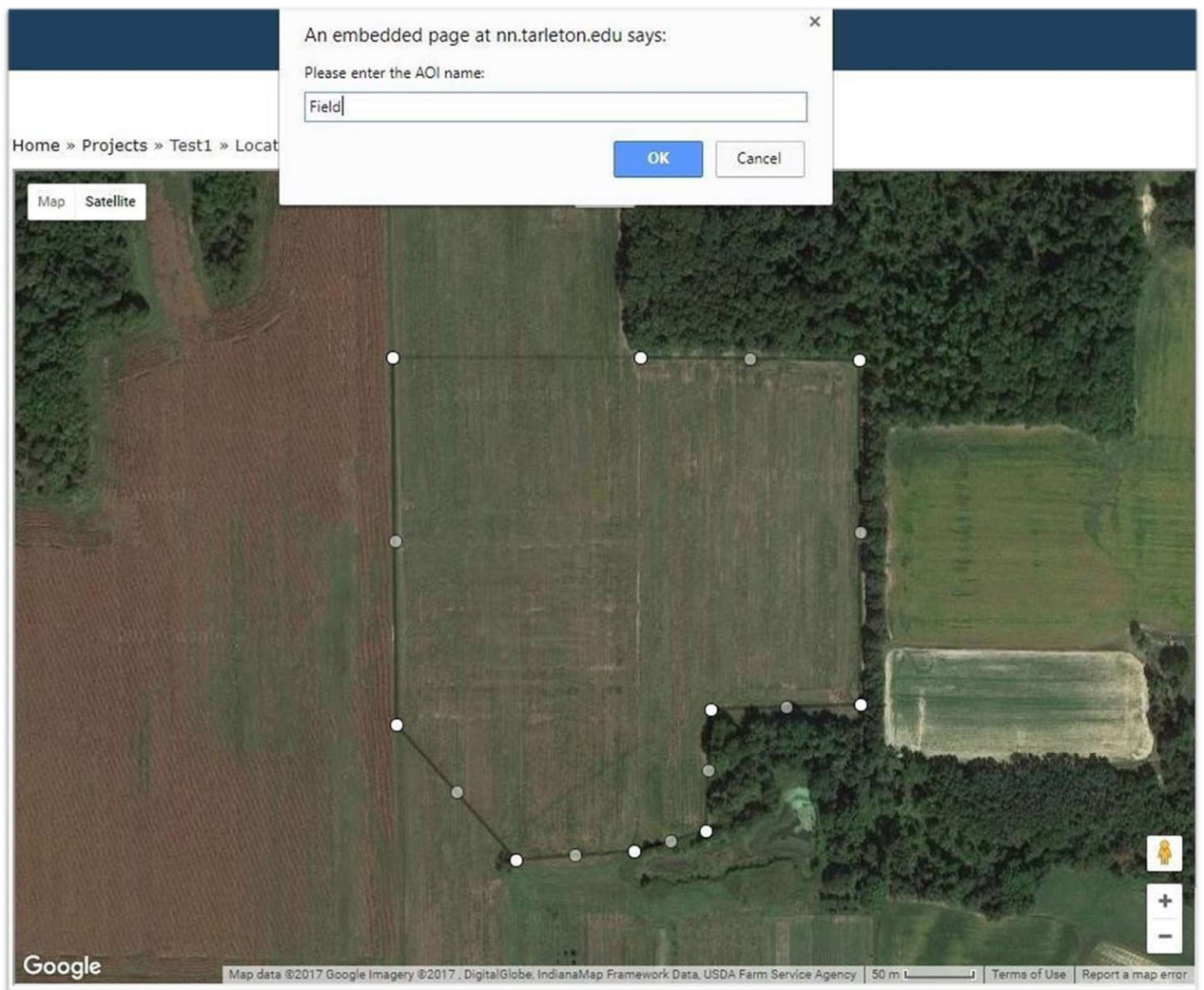
Figure 5: Location, Drawing AOI screen.

Figure 6: Location, Drawing AOI screen.

3. Submitting AOIs: Once you have one or more AOIs, you MUST click the Submit button to upload the map into the program.
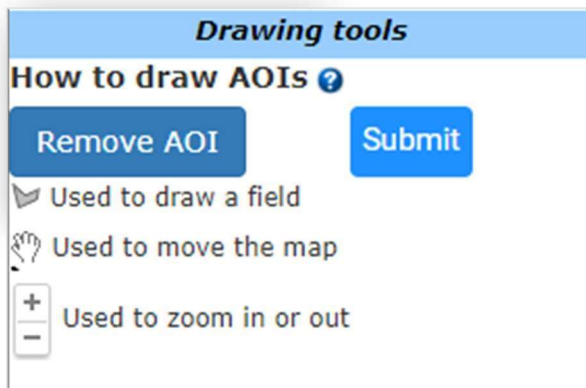
Figure 7: Location, Drawing AOI screen.

4. Deleting AOIs: To remove an AOI, first select the field that you would like to delete, and then click the Remove AOI button.

c) Upload Shapefile

If you already have a shapefile that you would like to use as your project area you may upload the shapefile. You will need to upload a file that consists of at least four files with the same name but different extensions (.shp, .shx, .dbf, and .prj). Ensure that the .shp file is the format of an Environmental Systems Research Institute (ESRI) Shapefile that uses the geographic coordinate system (latitude and longitude). The shapefiles need to be stored within a .zip folder, and you need to upload the .zip folder.

1. Choosing a Shapefile: Select the button Choose file located above the Upload button as shown in the figure (Figure 8):
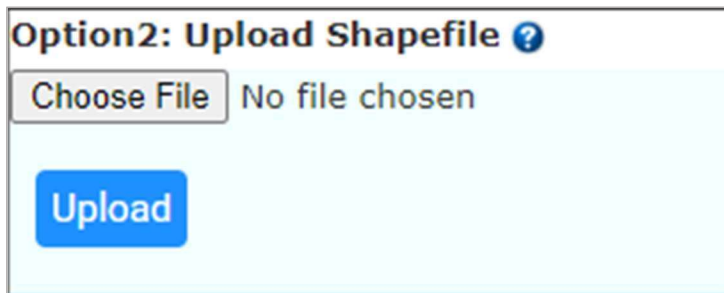
Figure 8: Location, Drawing AOI screen.

2. Uploading a Shapefile: Once you have located the shapefile (.zip folder) you wish to use, upload the file by clicking the Upload Shapefile button.

Submitting a Shapefile: You need to submit the changes to the map once you have uploaded the shapefile. Be sure to click the Submit button.

NTT Fields Page

The Fields page displays the AOIs/fields that you have defined for your project. From the Fields page, you can begin entering management practice information for each field. You may also delete fields/AOIs from your project on this page.

If you have uploaded shapefiles on the Location Page, they will be listed on the Fields page. This page allows users to verify or edit the field(s).

a) Deleting a Field

To delete field(s), simply click the ✖ icon in the Actions column.

b) Define Field Management

To begin defining management scenarios for your field, click on the hyperlinked field name to advance to the field-level Soils page for that field. You can change the field/AOI name as well as revise the field/AOI area on the Soil Page. (See Soils page for more information.)

c) Add Fields/AOIs

To add more fields or AOIs to your project, click Location on the left-hand navigation bar to go back to the Location page. From the location page you can draw and submit additional AOIs that will then appear on the Fields page.

d) Changing Field Name and Area

The field name and area can be changed on the Soils page. Simply click on the pencil in the Actions column. You will be able to modify the field name and area.

NTT Soils Page

After clicking on a field to begin editing on the Fields page, the user will be directed to the Soils page. The Soils page is a field-level page. The Soils page allows the user to rename the field and adjust the acres and verify soils retrieved from the SSURGO soils database for the field selected in the Fields page. NTT uses a maximum of 3 predominant soils for every field to minimize model processing time (Figure 9).

Fields that contain a diversity of soil types should be subdivided into to two or more AOIs to allow for more precise analysis of management practice scenarios.

Figure 9: Soils Screen.

a) Field Name/Area

Field Name: The name that the user has given to the AOI is pre-filled here. The user may modify the name if desired. The new name will be updated on the Fields page as well.

Field Area: Field area displays the calculated area of the field in acres. The user may refine this value if needed.

b) Display of Soils Information

The soils information box lists up to 3 predominant soils series names for the selected field as retrieved from the SSURGO Soils database. Following the soil series name are four columns containing information provided by the SSURGO Soils database. The column titled Group lists the soil type class, the Slope column lists the soil slope, the Drainage column lists the percentage of organic matter in the soil and the Percentage column lists the percentage of the field covered by that soil series. Because NTT selects only the top three most predominant soils, the coverage area of each is proportionally expanded to equal 100% coverage of the field.

Create New Soil: The user can create new soil layers in the soils table and modify the new soil(s) values, including the Group, Name, Albedo, Slope, Percentage, and Drainage Quality.

Management Scenarios

Overview

The Management Scenarios page is designed to allow users to create, manage, and simulate a variety of management scenarios or combinations of management practices for each field AOI. Users may create multiple scenarios for each field in order to compare how different crop management and conservation practices will impact nutrient losses and yields. The recommended procedure is to choose a baseline scenario with the typical management in the operations page, copy the baseline scenario, edit the scenario name in the management page, and then change one management scenario at a time in the operations page.

a) Creating a Management Scenario

Users can create a management scenario by clicking on the Create New Scenario button. Users will then be asked to name the scenario, for example "Baseline" or "Alternative" or "AutoIrrigation" or "Planting Corn" (Figure 10). After giving a name to the scenario, click the Save button to create the scenario and advance the user to the Operations page where the user will begin to define the crop schedule and conservation practices (Figure 11).
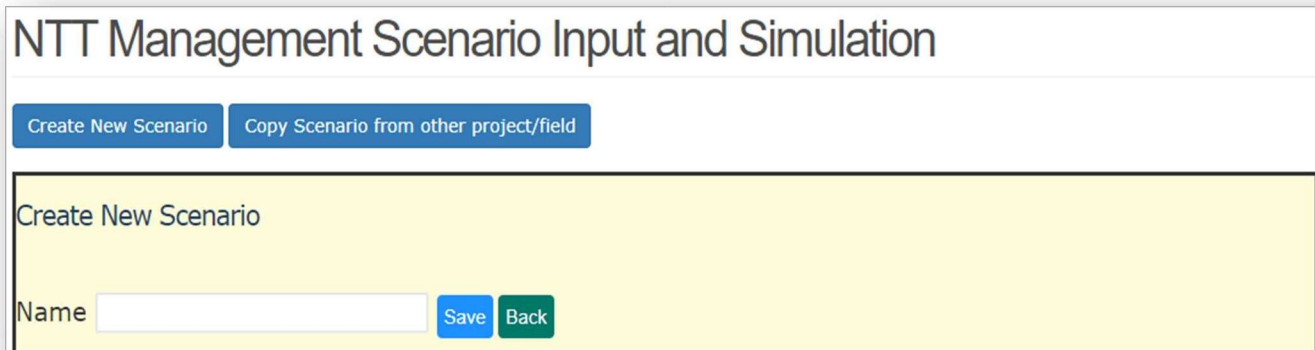
Figure 10: Create new scenario screen.

Figure 11: Management Scenarios screen.

b) Copy Scenario from another project/Field

Users can copy scenarios from previously defined fields and use them for other projects or fields. To copy scenarios, click "Copy Scenario from other project/field" at the top of the page, then select the project, field, and scenario that you wish to copy, then click the Copy button. The scenario will be copied and will appear in the list of management scenarios for that field. In addition, a scenario can be duplicated, renamed, and modified to describe different management scenario within a field by using the copy ⧉ icon under the Actions options. Each scenario should be selected and if necessary re-selected for simulation before comparisons can be made.

c) Management Scenarios for the Field

The Management Scenarios page includes a list of the scenarios created for the field (Figure 16). The list includes the scenario name and fields for Weather, Soils, Layers, Operations, Simulated (whether a simulation has been run), Simulation Date, and an Actions column. A green check ✔ will appear in the Weather, Soils, Layers and Operations columns when these are present for the scenario. In order to successfully simulate a scenario, all four of these elements must display the ✔ green check icon. The

Weather, Soils and Layers should be checked when a management scenario is first created, as these elements are derived from the map and are automatically associated with each field. However, the Operations column will be blank until the user enters management information for the scenario. A green check ✔ icon will appear in the Operations column once management information has been entered for the field.

The Simulation date field indicates the date on which the scenario was last simulated by the model. If the simulation date field is ⚠ it means that the field has not been simulated. If the scenario was changed in another field, the date will also assist the user in identifying whether the information needs to be updated (See Simulating Scenarios to learn more about how to simulate a scenario).

The Actions column contains different icons, representing different actions. The download APEX button allows you to download an APEX folder. The edit icon allows you to modify the scenario name. The copy icon creates a copy of your management scenario. And the delete icon will delete the management scenario (Figure 11).

Operations Page

To proceed to the operations page, click on the name of the selected management scenario.
A cropping system is REQUIRED for the user to be able to advance and simulate the NTT. The user can add rotations that are one year in length or much longer. A field may have multiple crops or a single crop. There are different options available in Operation Page for manipulating a cropping system (Figure 12)

Figure 12: Uploading crop to rotation screen.

To add a crop to the rotation, click Add Crop to Rotation. Users are provided with drop-down lists for selecting a crop tillage type (no-till, reduced till, or intensive till), and rotation year (Figure 12). The crop list is customized according to the region in which the project is located. The rotation year indicates the sequence of the crop within the crop schedule; it does not represent the calendar year. User can replace the current crop in rotation by selecting the "Replace Current Operation" icon. After selecting crop type, tillage type, and planting year, click Upload to add the crop to the crop schedule. Each crop added to the schedule includes several default management characteristics including a planting date, fertilizer applications, tillage schedule, and harvest date.

Figure 13: Operation Crop view screen.

Figure 14: Operation summary view screen.

a) Crop View

Once you add crops to your rotation, your view will default to the Crop View (Figure 14) where management actions are categorized by crop and operation type. Click the [+] next to a crop in the rotation to expand and view all the default crop operations. From here you can begin editing the crop management by editing the existing operations. The edit icon in the right column allows users to modify components of each practice listed while the delete icon allows users to delete the operation. See the Edit Operations section of this document for more information. Users may also click Add New Operations to

add additional operations. See the Add New Operations section below to view practice choices available and information required for each practice selected (Figure 16).
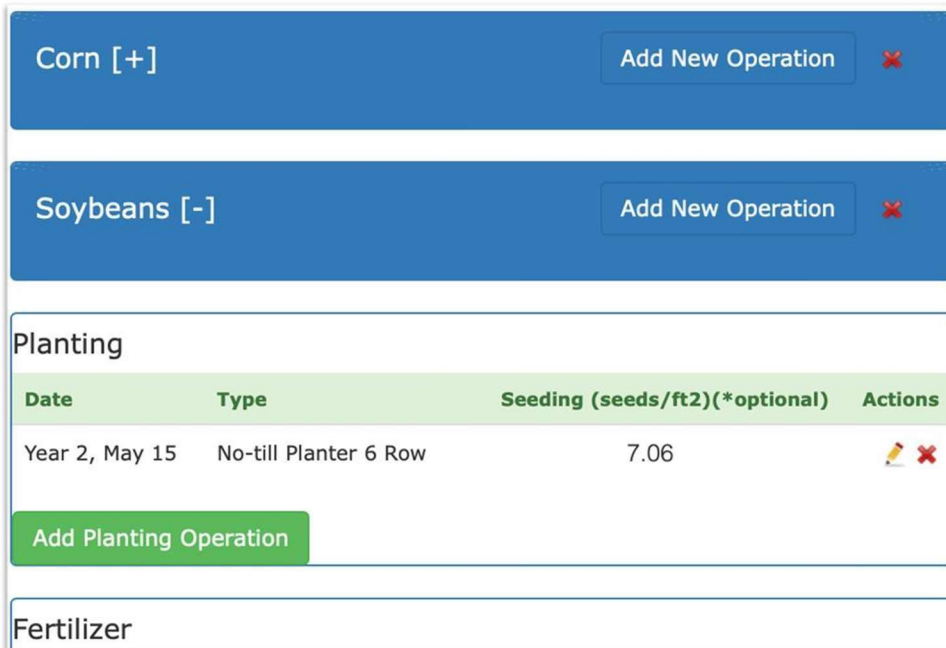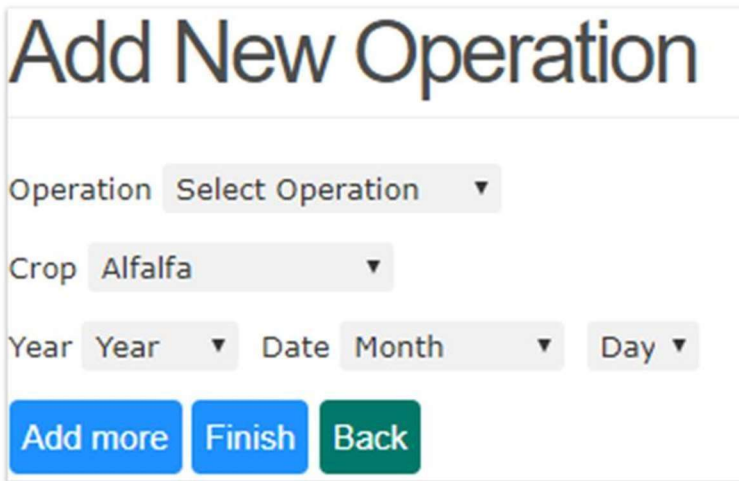
Figure 15: Operation screen.

b) Summary View

Click on Switch View to switch from the Crop View to the Summary View (Figure 14) and vice versa. The Summary View allows users to view the list of management practices chronologically for the entire rotation. The edit icon in the right column allows users to modify components of each practice while the delete icon allows users to delete an operation. Clicking on the Add More button within the practice edit screen (Figure 16) allows the user to build a new practice from scratch. Clicking Add More will also save changes to the current operation and allow the user to continue adding additional operations without returning to the Operations page. See the Add New Operations section below for more information.

c) Add New Operation

Users can add operations to their rotations or build a cropping system from scratch using the Add New Operation button (located to the right of every crop in the Crop View) (Figure 16). Users can select the crop, operation type, year, and date for each new operation. The year indicates the position of the operation in the crop schedule; for example, CORN year 1 and SOYBEAN year 2.

Figure 16: Adding new operation screen.

d) Type of Operations

Depending on the operation type, there will be additional data to enter. Below are descriptions of the different operation types and the additional data required for each:

1) Planting

- Planting Method: User must indicate the planting method, using the list of planting equipment provided.

- Seeding Amount (seeds/sq. ft.): This field is pre-filled with standard seeding rates for each crop type. If the user has more specific information on the seeding rate, they may enter it here.

2) Fertilizer & Manure

- Fertilizer Category: User must indicate the fertilizer category (commercial, liquid manure, or solid manure).

- Fertilizer Type: The fertilizer type list will vary depending on the fertilizer category selected. For manure fertilizer, the list will contain types of animal manure.

- Amount: Users need to indicate the amount of fertilizer applied. Units will vary depending on the type of fertilizer selected (lbs./ac, tons/ac, 1000 gals/ac).

- Depth: If the fertilizer is incorporated, user should indicate the depth of incorporation here. If fertilizer is not incorporated, this field can be left blank.

- Fertilizer Composition (commercial fertilizer only): For commercial fertilizers, these fields indicate the N and P composition. These fields are pre-filled based on the fertilizer type selected but can be modified if needed.

- Ammonia N: This the fraction soluble N in ammonia form.

- Total N concentration (solid/liquid manure only): For manure fertilizer, the user should indicate the total N content per ton of solid manure or per 1000 gallons of liquid manure. Typical values are pre-filled for the user but can be modified.

- Total P concentration (solid/liquid manure only): For manure fertilizer, the user should indicate the total P content per ton of solid manure or per 1000 gallons of liquid manure. Typical values are pre-filled for the user but can be modified.

- Moisture content (solid/liquid manure only): For manure fertilizer, this is the percentage, by weight, of moisture content in the manure. Typical values for each manure type are provided, but can be modified by the user.

3) Tillage

There are two options for adding and/or modifying tillage operations:
1. Using the tillage option (no-till, reduced till, and intensive-till) during crop selection in the operation page (Figure 17)
2. Selecting or modifying under Adding Operation option.

4) Harvest Only

• Harvest: No additional data needed beyond the crop, year, and date.

5) End of Season

- End of Season: End of Season requires only the crop, year, and date information from the user. End of season also indicates to the model that the crop is removed from the field. If an End of Season operation is not inserted, the model assumes that the crop continues growing. End of Season should be used for all annual crops. For certain perennial crops like hay and pasture, End of Season operations may be absent from the crop schedule.
- Harvest and end of crop season: user can combine the harvest and end of season operations together by this option.

6) Manual Irrigation

- Irrigation method: The user indicates the type of irrigation system that is being used.

- Amount: The user indicates the inches of water applied during the irrigation event.

- Irrigation efficiency: This field defaults to a typical irrigation efficiency value (as percentage) based on the selected irrigation method.

7) Continuous Grazing

Under the continuous grazing management practice, the animals are grazing in the field for a specific number of hours (up to 24 hours) a day for part of the year.

- Start/End Grazing dates: User indicates the start and end dates of grazing in the field. For example, January 1 to December 30 for the selected year.

- Animal Type: User indicates the type of animals grazing in the field.

- Animal Units: User indicates the total animal units (AUs) grazing in the field (scenario AOI). Table 1 shows the class of animals and the AU equivalent.

Table 1. Class of Animals and AU Equivalent
(from USDA-NRCS range and Pasture Handbook)

Class of Animal	Animal Unit Equivalent
Cow, 1000 lbs.	0.92
Cow, 1000 lob, with calf	1.0
Bull, Mature	1.35
Cattle, 1 year old	0.60
Cattle, 2 year old	0.80
Horse, Mature	1.25
Sheep, Mature	0.20
Bison, Mature	1.0

8) Rotational Grazing

The rotational grazing operation, unlike continuous grazing, assumes that the pasture is divided into paddocks and that livestock are moved through the paddocks as needed. Thus, each paddock is given a recovery period between grazing events, which improves vegetative cover.

- Hours in Field: Users indicate the total hours per day that animals are grazed in the field.

- Start/End Grazing dates: User indicates the start and end dates of grazing on the field.

- Animal Type: User indicates the type of animals being grazed on the field.

- Animal Units: User indicates the total AUs being grazed on the field (scenario AOI). Table 1 shows the class of animals and AU equivalent.

- Number of consecutive days grazed at a time (in each paddock): User indicates the number of days livestock will spend in each paddock before being rotated to a new paddock.

- Pasture rest time (days) between grazing: User indicates the number of days that the pasture is rested between rotational grazing cycles.

9) Burn Operation

• No additional data required by users beyond crop, year, and date.

10) Liming

- Start/End dates: User indicates the start and end dates of lime application on the field.
- Amount: User must insert the amount of lime applied (lbs./ac).

e) Editing Operations

Users may change the values or any other information in an operation by clicking on the Edit 🖉 icon in the Actions column next to the operation. Once the operation has been edited, click Finish to save and return to the Operations page (Figure 17). Clicking back will return the user to the Operations page without saving changes to the operation. Clicking Add More will save change to the current operation and allow the user to continue adding additional operations without returning to the Operations page.
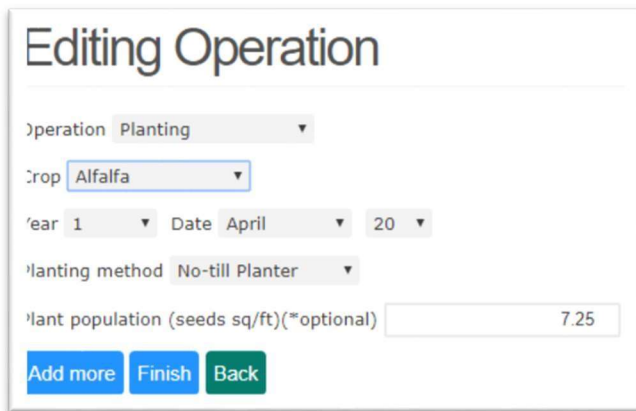
Figure 17: Editing operation screen.

f) Deleting an Operation

To delete an operation, click the Delete icon ✖ in the Actions column of the operation you wish to delete. By clicking Switch View at the top of the page, you can switch your view from one that is organized by crop and operation type to one that is organized by date. Once you are satisfied with your crop schedule, click Continue at the top of the page. You will be advanced to the Conservation Practices page where you can indicate any conservation practices that are present in the field.

g) Add a Cover Crop

To add a cover crop, click the Add Cover Crop button at the top of the "operations" page. Users need to select the type of cover crop, cover crop year, planting date, and planting method. The cover crop year should match the year within the rotation that the cover crop is planted. NTT will automatically add the "end of the year" operation for the cover crop before the first operation for next year's crop in the rotation. Cover crops are not fertilized and are not harvested, rather they are removed prior to planting of the next crop in the rotation.

Note: If you wish to add a commercial cover crop, please do so as you would add another crop to your crop rotation schedule. For example, add "Winter Wheat" to your crop schedule by clicking Add Crop to Rotation and selecting from the crop pick-list, and DO NOT use the "Add Cover Crop Operation" button. Adding a crop this way allows users to apply fertilizer, tillage and harvest operations etc.

h) Structural Practices

Once the crop schedule and operations has been completed click Continue to Conservation Practices at the top of the page which will advance the user to the Structural Conservation Practices page. On this page users will indicate the structural conservation practices that are in place in the field. The user can click Save within each option to save all practices that have been selected. If no conservation practices are in place in the field, simply click Continue to Operations at the bottom of the Conservation Practices page,

which will return the user to the Operations Page (Figure 12). Note: If any practices remain selected or deselected the Continue to Operations button may save and overwrite any changes made by the user.

Alternately, users may navigate directly to the Management Scenarios page using the left-hand navigation links.

☐	Autoirrigation/Autofertigation
☐	Tile Drain
☐	Wetlands
☐	Ponds/Water & Sediment Control Basin
☐	Stream Fencing (Livestock Access Control)
☐	Streambank Stabilization (Restoration)
☐	Grass Buffer/Forest Buffer
☐	Grass Waterway
☐	Contour Buffer
☐	Land Leveling
☐	Terrace System
☐	Auto Lime Application

Figure 18: Conservation practices screen.

To add a structural conservation practice, click on the check box in the Select column of the structural conservation practice you wish to add. The structural conservation practices are organized by groups, and you may select the specific practice in which you are interested. To add a practice, you need to expand the particular group by clicking the check box next to the select group. Then, select the specific option within the group that you wish to add and fill in any required fields.

You may add more than one structural conservation practice for a field, although some conservation practices are mutually exclusive.

Below are the descriptions of the conservation practices that are available in NTT:

1) Autoirrigation and Autofertigation

Figure 19: Adding Autoirrigation/Autofertigation in Conservation practices screen.

Autoirrigation refers to Automatic irrigation systems, which are irrigation systems that are controlled by a computerized controller. Autoirrigation overall can greatly increase crop yield. Within NTT, the autoirrigation feature assumes the field will be irrigated when certain user-supplied criteria for water stress and frequency are met, and will limit the calculated water application to the user supplied maximum application amount. Autofertigation is an automated fertilization application (lbs/ac) event by which N fertilizer is applied with the irrigation water. The only difference between autofertigation and autoirrigation is the addition of nitrogen to the irrigation water.

User inputs required for autoirrigation include:

- Irrigation Type: Irrigation types include sprinkler, furrow/flood, drip, and furrow diking.

- Irrigation Efficiency: This value is the percentage (0-100) of irrigation water that is in the soil. The value must be greater than 10% and less than 90%. The lower the value of irrigation efficiency, the greater the percentage of irrigation water lost as runoff. Different irrigation systems have different irrigation efficiencies. NTT provides the typical irrigation efficiency values for the irrigation type selected, but these values can be modified by the user.

- Irrigation Frequency (0-365) days: This field asks for the maximum frequency (in days) that irrigation can take place. If the frequency is set to 365, then irrigation can occur every day. If frequency is set to 7 then irrigation can occur, at most, once a week. The value can be any whole number greater than or equal to zero and less than or equal to 365.

- Plant Water Stress Factor: The water stress factor indicates the water stress level of the crop. This is the value that is used to trigger the start of automatic irrigation. For example, if water stress is set to 0.8 then NTT will trigger an irrigation event when the crop is 20% water-stressed, if conditions for maximum frequency are also met. The plant water stress factor can be any value greater than 0 and less than or equal to 100%. The closer the value is to 100%, the less water stress is allowed before the automatic irrigation is turned on.

- Maximum Single Application: This value signifies the maximum amount of water than can be applied in a single irrigation event. It is in inches, and it can be any number greater than 0. If there are no constraints on the maximum single application, this value should be set to a high number.

- Maximum N Application rate (autofertigation only): If the user is fertigating, this field will indicate the maximum amount of nitrogen fertilizer (as elemental N) that is applied to the crop through fertigation. This amount will be applied over the irrigation season and will be in addition to any nutrient applications specified in the fertilizer operations (please see note below for guidance on how to represent manure fertigation).

- Start and End Date: You also can select the start and the end data of autoirrigation/fertigation within a rotation year.

Note: Nutrients applied through autofertigation are in addition to the nutrients from commercial and manure fertilizers applied to the crop as part of fertilizer operations. If you spray liquid manure on your field periodically, it is best to represent this as a manure application and not through the autofertigation feature because manure contains more nutrients than N.

2) Tile Drain

Tile drainage is a practice for removing excess subsurface water from agricultural soils using perforated pipes. Drainage brings excessive soil moisture levels down for optimal crop growth. Drainage is often the best recourse for reducing high subsurface water levels to improve crop yields. Too much subsurface water can be counterproductive to agriculture by preventing root development and inhibiting the growth of crops. Excessive water can also limit access to the land, particularly by farm machinery. Drainage is common in some agriculture areas and unnecessary in others. Recommendations are to base the tile drain scenario on poorly drained soils, which can be found in the NTT Soils Page instructions. The depth of the drainage system to reduce plant stress is a key parameter used in simulating tile drainage systems in NTT. Tile drainage simulation in NTT increases subsurface flow, which may provide an avenue for increased nutrient losses in subsurface flow. The only input for tile drains is depth. There are checkboxes for Tile Bioreactors and Drainage Water Management, and Saturated Buffer, respectively, which are part of the tile drain management System.

- Tile Bioreactors: Bioreactors are a subsurface trench filled with a carbon source, usually wood chips, through which water is allowed to flow before leaving the tile drain and entering a surface waterbody. To enable Bioreactors, place check the box beside this practice. According to Iowa Department of Natural Resource Guidelines, the default nitrate reduction value for this practice is set at 43%.
  https://www.iowadm=nr.gov/Portals/idnr/uploads/water/wse/isu_reducingnutrientloss.pdf).
- Drainage Water Management: Drainage water management is the process of managing water discharges from surface and/ or subsurface agricultural drainage systems with water control structures. By controlling the flow, nutrient losses can be reduced. Place a check beside the practice to enable it.
- Saturated buffer: A saturated buffer is an area of perennial vegetation between agricultural fields and waterways where tile outlets drain. Tile lines connect to a control structure, which distributes water laterally along the buffer. As water drains into the buffer, the living roots of perennial vegetation absorb water and nutrients. This practice must be paired with a buffer in NTT. To enable the practice, place a check in the appropriate box. The user will also be asked to provide the length of the distribution pipe or the estimated fraction of tile flow released to the saturated buffer (0-1.0). Note: Grass Buffer/Forest Buffer must also be selected to use the Saturated Buffer option.

3) Wetlands

Wetlands are those areas that are inundated or saturated by surface or groundwater at a frequency and duration that under normal circumstances support a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs and similar areas.

The wetland area is simulated as a shallow reservoir (1 ft. depth) but also includes growing wetland vegetation – it is essentially simulated as an artificial wetland and not a natural wetland. The slope of wetland area is set as 1%. Simulated wetlands trap sediment, reduce runoff, increase infiltration, and also increase uptake of water and nutrients by the vegetation in the area covered by the wetland. Inputs required for wetlands include:

- Area: The area of the wetland is input in acres. Since this area is no longer able to be used for crop production, there may be a lower total crop yield (although there may be a greater crop yield/acre).
- Is wetland area included in your AOI? Users indicate whether the AOI representing the field includes the wetland feature within the drawn polygon or if the wetland feature lies outside of the AOI. If the wetland feature is included in the AOI, then the wetland acres will be subtracted from the field area.
- Recommendation: Wetlands need proportionally sized for AOIs. If the AOI is too large, the only difference that may be simulated would be from the Total area tab in the simulation page. If this user error occurs, one solution is to choose a much smaller AOI.

4) Ponds/Water and Sediment Control Basins

Water and sediment control basins (WASCOBs), or ponds, consist of an embankment across the slope of a field or minor waterway to temporarily detain and release water through a piped outlet or through infiltration. They are constructed perpendicular to the flow direction and parallel to each other. WASCOBs are usually installed in areas where the land is relatively steep and undulating. They detain water from contributing areas, inducing sedimentation and controlling the release of water, thereby reducing the erosive power of the water downstream. Additional benefits of WASCOBs are the settling of sediment-bound pollutants and some infiltration. Only one input is required for ponds: fraction of area controlled by ponds. Note that ponds/WASCOBs are considered to be in-field practices.

  • Fraction of Area Controlled by Ponds/WASCOB: This is the fraction (a value between 0 and 1. 0) of the field runoff that flows through (is controlled by) the pond/WASCOB. As modeled, ponds only treat runoff that originates in this field. Inflow from other fields is not routed through the ponds. Ponds/WASCOBs are assumed to be within field.

5) Stream Fencing (Livestock Access Control)

Stream Fencing (SF) is used to keep cattle out of streams, and consequently is seen as a way to improve water quality. Fencing will prevent animal defecation in streams, which constitutes a direct contribution of manure nutrients and pathogens to the surface water resource. In addition, SF prevents bank erosion and protects the aquatic habitat.

Stream Fencing is simulated by Adding New Operation in the Operation page. User must select either Grazing, continuous or Grazing, rotational from the operation drop-down box. Within the grazing operation details page, the user must check on the "Animals have access to stream?" checkbox and provide Hours in order to be able to have access to SF.

In NTT, SF eliminates or reduces direct nutrient deposition in streams as point source and stops the destabilization of stream banks that is often caused by livestock traffic. This is done by simulating the area between the fence and edge of stream as FS (field strip). The user has the choice to describe the area, efficiency, and the type of grass growing for the new FS. It is important to know that NTT does not allow the selection of another FS for the same stream channel from the "management Information" page.

The defecated manure from animals in the stream is considered as a point source of nutrients in the water. The amounts of nutrients (N and P) in solid and liquid forms are calculated based on the type of manure produced from the specific animal (provided by the user or default values) and the months of the year in which the animals spend a portion of their time in the stream. NTT uses the SF information in calculating the N and P losses to surface water.

6) Streambank Stabilization (Restoration)

Erosive stream banks are re-shaped and seeded, and sometimes protected with rock rip-rap or seeded with bio-engineering materials under this management practice. Stabilizing the streambanks

protects water quality, improves fish habitat, and the vegetation provides habitat for birds and small animals.

The inputs for Streambank Stabilization (Restoration) are the following:

- Streambank Stabilization: Stream bed is stabilized to prevent channel erosion and nutrient losses under this practice.
- Streambank Restoration: Stream bed is stabilized and vegetated to prevent channel erosion and nutrient losses under this practice.
- Width (ft): This is the width, in feet, including both sides of the vegetated channel. This can be any number greater than 0.

7) Grass Buffer/Forest Buffer

When selecting "Grass Buffer/Forest Buffer" the user will be asked to indicate type of buffer. Inputs for each type of buffer vary slightly.

8) Forest Buffer

Forest buffers are linear wooded areas with well-developed root systems, an organic surface layer, and understory vegetation. When they are adjacent to open water they are referred to as riparian buffers. Non-riparian buffers are linear wooded areas along down-slope field edges.

Forest buffers trap sediment and increase infiltration, thereby reducing sediment and nutrient losses. Forest buffers often include a grass buffer between the field and the forested buffer. If present, the width of the grass buffer should be included.

The inputs for Forest Buffer are the following:

- Area (ac.): This is the total area of the buffer. This field is optional. If left blank, the area will automatically be calculated using the width of the buffer and the length of the field edge (where the field edge is calculated as the square root of the area of the field).

- Grass Strip Width (ft.): This is the width of the grass strip between the crop and the forested buffer, if present.

- Forest Buffer Strip Width (ft.): This is the width of the forest buffer (not including the grass strip).

- Fraction of field treated by buffer: This is the estimated fraction (0.00-1.00) of the runoff from the field that is routed through the buffer. The percentage of the AOI that slopes toward the grass buffer is used to determine the fraction.

- Is buffer included in AOI?: If the buffer has been drawn as part of the AOI, then the area will be subtracted from the crop area. If it has not been drawn as part of the AOI, it will be assumed to be adjacent to one edge of the field.

9) Grass Buffer

Grass buffers, also known as filter strips, are areas of vegetation, generally narrow in width and long across the downslope edge of a field, that slow the rate of runoff, allowing sediments, organic matter, and other pollutants being conveyed by the water to be removed by settling out. FS reduce erosion and the accompanying sediment-bound pollution.

In NTT, FS function by providing for better infiltration of soluble nutrients, trapping of sediment, and increased uptake of water and nutrients by the FS vegetation. The saturated conductivity value is also modified for FS simulation in NTT.

The inputs for grass buffers are

- Vegetation Cover: User selects the type of grass or vegetation that is planted in the buffer.

- Area (ac.): This is the total area of the buffer. This field is optional. If left blank, the area will automatically be calculated using the width of the buffer and the length of the field edge (where the field edge is calculated as the square root of the area of the field).

- Grass Strip Width (ft.): This is the width of the grass strip between the crop and the forested buffer, if present.

- Fraction of field treated by buffer: This is the estimated fraction (0.00-1.00) of the runoff from the field that is routed through the buffer. The percentage of the AOI that slopes toward the grass buffer is used to determine the fraction.

- Is buffer included in AOI?: If the buffer has been drawn as part of the AOI, then the area will be subtracted from the crop area. If it has not been drawn as part of the AOI, it will be assumed to be adjacent to one edge of the field.

10) Grassed Waterway

A grassed waterway is a natural or constructed swale, shaped or graded, that is established in suitable vegetation for the safe conveyance of runoff. Grassed waterways are designed to prevent soil erosion while draining runoff water from adjacent cropland. As water travels down the grassed waterway, the grass vegetation prevents erosion that would otherwise result from concentrated flows and the associated uptake of nutrients. Grassed waterways also help prevent gully erosion in areas of concentrated flow. For example, they may be used to drain runoff from terraces and runoff water diversions. By intercepting runoff, grassed waterways slow erosion and minimize nutrient losses. The inputs for Grassed Waterways include:

- Vegetation Cover: The type of grass or vegetation growing in the channel.

- Width: The width of the grassed waterway, in feet, including both sides of the vegetated channel. This can be any number greater than 0.

- Fraction of field treated by grassed waterway: The fraction of the field that drains to the grassed waterway. A number between 0.00 and 1.00.

11) Contour Buffer Strips (Strip Farming)

Contour buffer strips are permanent, narrow bands of grasses/legumes planted on the contour (across or perpendicular to a slope) between wider strips of crops. Contour buffers trap sediment and enhance filtration of nutrients and pesticides by slowing down runoff that could enter the local surface waters. User inputs for contour buffers include:

- Vegetation Cover: The type of grasses/legumes vegetation that will be present in the buffer sections of the contour buffer.

- Contour buffer Width (ft): The width, in feet, of the buffer strips. It can be any number greater than 0. Buffer width, along with crop width, determine the number of buffer and crop strips in the field.
- Crop strip Width (ft): The width, in feet, of the strips of the main crop that was planted. It can be any number greater than 0. Crop width, along with buffer width, determine the number of buffer and crop strips in the field.

12) Land Leveling

Land leveling is used to reduce the slope on high soil slopes. By reducing the slope, the surface land is better able to retain water and soil, reducing erosion and increasing infiltration. The input for land leveling is slope reduction percentage. User input includes:

• Slope Reduction: This is the percent reduction in the slope of the soil that results from leveling the land. The number can be any percentage between 0% and 100%. The closer the leveled slope is to 100%, the more the slope has been reduced.

13) Terrace System

A terrace system is a leveled section of a hill's cultivated area, designed as a method of soil conservation to slow or prevent the rapid surface runoff of water. Terraces decrease hill slope length, reduce formation of gullies, and intercept and conduct runoff to a safe outlet, thereby reducing sediment content in runoff water. Often, the landscape is formed into multiple terraces, giving a stepped appearance. Terraces are simulated by reducing the practice factor (PEC). To apply a terrace system, click on the Select button.

14) Reservoir

Reservoirs are constructed on the farmland by producers to treat wastewater and contaminated runoff from agricultural processing, livestock, and aquaculture facilities. A well-constructed reservoir could improve the quality of storm water runoff or other contaminated water by withholding runoff water. The reservoir area is simulated at the outlet of the simulated farm the slope of reservoir is set as one percent.

The following information is needed by the user to simulate reservoirs in NTT program:

• RSEE: Elevation at emergency spillway (ft)
• RSAE: Total reservoir surface area at emergency spillway elevation (RSEE) in ac.
• RSVE: Runoff volume from reservoir catchment area at emergency spillway elevation in mm.
• RSEP: Elevation at principal spillway (ft)
• RSAP: Total reservoir surface area at principal spillway elevation (RSEP) in ac.
• RSVP: Volume at principal spillway elevation in inches.
• RSV: Initial reservoir volumes in inches.
• RSRR: Average principal spillway release rate in days. Days to draw down from the emergency spillway to the principle spillway volume
• RSYS: Initial sediment concentration in reservoirs in ppm.
• RSYN: Normal sediment concentration in reservoirs in ppm.
• RSHC: Hydraulic conductivity of reservoir bottoms in in/h.
  RSDP: Time required in days for the sediment in the reservoir to return to the normal concentrations following a runoff event (Range: 0-365).
• RSBD: Bulk density of sediment in reservoir (gr/kg)

15) Auto Lime Application

Auto Lime Application enables the user to simulate application of agricultural limestone to increase soil pH and/or reduce soil aluminum saturation. For many soils and applications of APEX, this feature is not needed; therefore, it can be turned off.

Lime Application Switch;
    Checked = Applies Lime As Needed Automatically;
    Unchecked = No Lime Applied automatically. The user could use the "Add new operation page" to manually insert a lime application operation.

Simulating Field Scenarios

Once one or more management scenarios have been defined, users may simulate their scenarios by placing a check the box next to the scenario name and clicking the Water Quality Simulation or Economic & Water Quality Simulation buttons (Figure 20). The water quality simulation will run the selected projects through the APEX model, which will return results for estimated nutrient and sediment losses as well as crop yields. Running the Economic and Water Quality simulations will run the scenarios in APEX and FEM. In addition to the water quality outputs, users will also be able to view simulated economic costs and returns based on their management scenarios.

Before attempting to simulate a scenario, please remember that green checkmarks ✔ in the weather, soils, layers, and operations columns are present. Each of these elements must be present in the scenario before it can be successfully simulated by the APEX model. Simulation of the scenarios may take one or more minutes. Basic simulation recommendations include selecting one scenario at a time, using an Ethernet cable connection for field routing and other complications, and being patient if a simulation includes a complex set of management practices.

Once a scenario has been successfully simulated, the simulation date field will show the date and time of the most recent simulation.

Note: Modifying a management scenario requires a re-simulate the scenario in order to obtain results of the updated scenario. If the scenario was copied into other fields before modifications, the simplest solution is to re-copy and re-simulate.

Select ■	Name	Weather	Soils	Layers	Operations	Simulated	Simulation date	Actions
☐	Planting Corn	✓	✓	✓	✓	✓	2023-10-05 14:23:05 -0500	⬇APEX ⬇FEM ✏ 🗐 ✖
☐	Planting Alfalfa	✓	✓	✓	✓	✓	2023-10-05 14:23:29 -0500	⬇APEX ⬇FEM ✏ 🗐 ✖
☐	Planting Cotton	✓	✓	✓	✓	✓	2023-03-22 13:26:04 -0500	⬇APEX ⬇FEM ✏ 🗐 ✖
☐	Planting Corn Grazing	✓	✓	✓	✓	✓	2023-09-21 08:15:54 -0500	⬇APEX ⬇FEM ✏ 🗐 ✖

Figure 20: Simulating a scenario in scenarios screen.

Viewing Results

To view the results on one or more field scenarios, the user may click on Results in the left navigation menu under Water Quality Results.

Results Page

The results page allows you to view the results for the field/scenario combinations simulated. You cannot review the results unless the field/scenario has been simulated. Please see simulating scenarios for more information.

a) Viewing the Results

To view the results on one or more field scenarios, the user may click on Results in the left navigation menu under Water Quality Results (Figure 21). After clicking on any of the Results, the user will be directed to the Tabular Results view page as a default. Users may also choose to view data in graphical view by clicking "Annual" or "Monthly" on the side navigation menu.
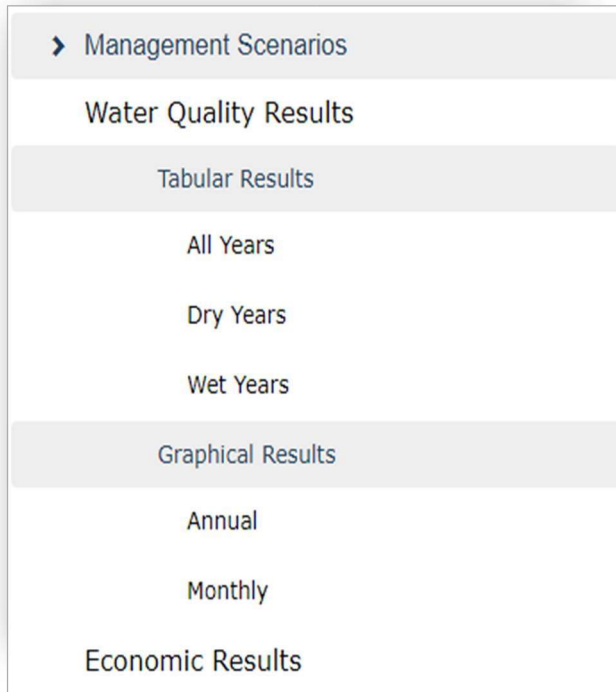
Figure 21: Side navigation bar.

b) Tabular View

To compare the results of one or more scenarios in the tabular view, use the drop-down menu on the top right of the tabular table to select each scenario to be compared. The user must select an Initial year and a Final year before selecting a field scenario (Figure 22). The report will present the average annual results for the selected scenarios over the selected time period (Figure 23).

The user may view results in units/acre or as total units summed across the area of the field. Typically, the units/acre view is selected. The table will populate with the results of each scenario. Users have the option of downloading the results as a comma-separated value (CSV) file or a portable document format (PDF) file.

Figure 22: Select Initial/Final year in Results screen.

c) Interpreting Tabular Results

All Years

Initial year   Final year   ⦿ Per Acre   ○ Total Field Area

1990   ⌄   2000   ⌄   Download PDF   Download Excel

(±) = Confidence Interval

Description	Planting Corn ⌄	❌ Planting Alfalfa ⌄ ➕	
	Losses (±)	Losses (±)	Change (%)
Hydrology (in) ❷ ☑			
Surface Runoff (in)❷	5.78 (1.8)	0.77 (0.5)	-5.01 (-86.7)
Subsurface Flow (in)❷	1.3 (0.3)	0.44 (0.4)	-0.86 (-66.2)
Tile Drain Flow (in)❷	6.45 (1.4)	0 (0)	-6.45 (-100.0)
Irrigation Applied (in)❷	0 (0)	0 (0)	0 (0)
Deep Percolation (in)❷	0.85 (0.2)	0.28 (0.3)	-0.57 (-67.1)
Precipitation (in)❷	32.62	32.62	0 (0)
N Losses (lbs) ❷ ☑	**48.25 (18.7)**	**0.27 (0.1)**	**-47.98 (-99.4)**
Organic N (lbs)❷	0.95 (0.6)	0.04 (0)	-0.91 (-95.8)
Runoff N (lbs)❷	29.75 (13.3)	0.22 (0.1)	-29.53 (-99.3)
Subsurface N (lbs)❷	0.8 (0.2)	0.01 (0)	-0.79 (-98.8)
Tile-Drain soluble N (lbs)❷	16.75 (4.6)	0 (0)	-16.75 (-100.0)
Deep Percolation N (lbs) ❷	**4.21 (1.3)**	**0.00 (0)**	**-4.21 (-100.0)**
P Losses (lbs) ❷ ☑	**1.33 (0.7)**	**0.08 (0.1)**	**-1.25 (-94.0)**
Organic P (lbs)❷	0.18 (0.1)	0.01 (0)	-0.17 (-94.4)
Surface Soluble P (lbs)❷	1.13 (0.6)	0.07 (0.1)	-1.06 (-93.8)
Tile-Drain soluble P (lbs)❷	0.02 (0)	0 (0)	-0.02 (-100.0)
Total Sediment (t) ❷ ☐	**0.14 (0.1)**	**0.01 (0.0)**	**-0.13 (-92.9)**
Carbon Sequestration ☐			

Figure 23: Detailed results table in Results screen.

The scenario results presented in the Results table represent AVERAGE annual edge of field losses across the years selected by the user. NTT simulates over a period of 35 years, but users can choose to summarize results over a shorter timeframe (Figure 24). Note that user can view year-by-year results in the graphical reports section (see Viewing Graphical Results). The name of the first Scenario will appear at the top of the first Losses column. This column displays the nutrient, sediment and flow losses at the edge of the field for Scenario 1 in addition to the estimated yields. Scenario 1 is the first column of data, Scenario 2 results are represented in the next column and highlighted in a different color. In addition to displaying results in the "Losses" column, Scenario 2 also has a "Change" column that represents the change in losses between Scenario 1 and Scenario 2. Scenario 3 results are also highlighted in another color. The Change column represents the change in losses between Scenario 1 and Scenario 3, and so on.

NTT is designed to compare a baseline scenario with one alternative scenario at a time. Because of this, it is assumed that the user will be looking for improvements in the alternative scenario. For example, in "Total Nitrogen" results the negative numbers in the difference and reduction % represent a desirable result (e.g. decreased losses as compared to Scenario 1) and positive numbers indicate an undesired result (e.g. in losses as compared to Scenario 1). This is reversed in crop yield results (e.g. Positive results shows increase in yield).

d) Viewing Results Graphically

1. Annual Chart (Entire Period): In addition to being able to view your results in tabular form, NTT also provides the option of viewing results graphically. There are two graphical views for the user to select: annual and monthly results. The user can select these views using the left navigation menu.
   Annual Charts (Selected Years): Annual charts allow users to view the annual average losses for a specific constituent (for example flow or sediment) for any specified of the simulation period. To select the annual view, click Annual-Chart in the left navigation menu. Once this option has been selected, the user will select the simulation period, scenarios they would like to compare, and the constituent they would like to view, as shown below. This will bring up the selected results on the graph. In addition to the graph, the annual results are displayed below the graph in tabular form and can also be exported (Figure 24).

Figure 24: Graphic average annual results in Results screen.

2. Monthly Chart (Entire Period): The monthly chart view allows users to view monthly average losses or gains for particular constituents over the period of the simulation (35 years) (Figure 25). To view the monthly chart, click Monthly-Chart from the left-hand navigation menu. Monthly charts are limited to constituents that APEX summarizes monthly. (See dropdown list of options below).
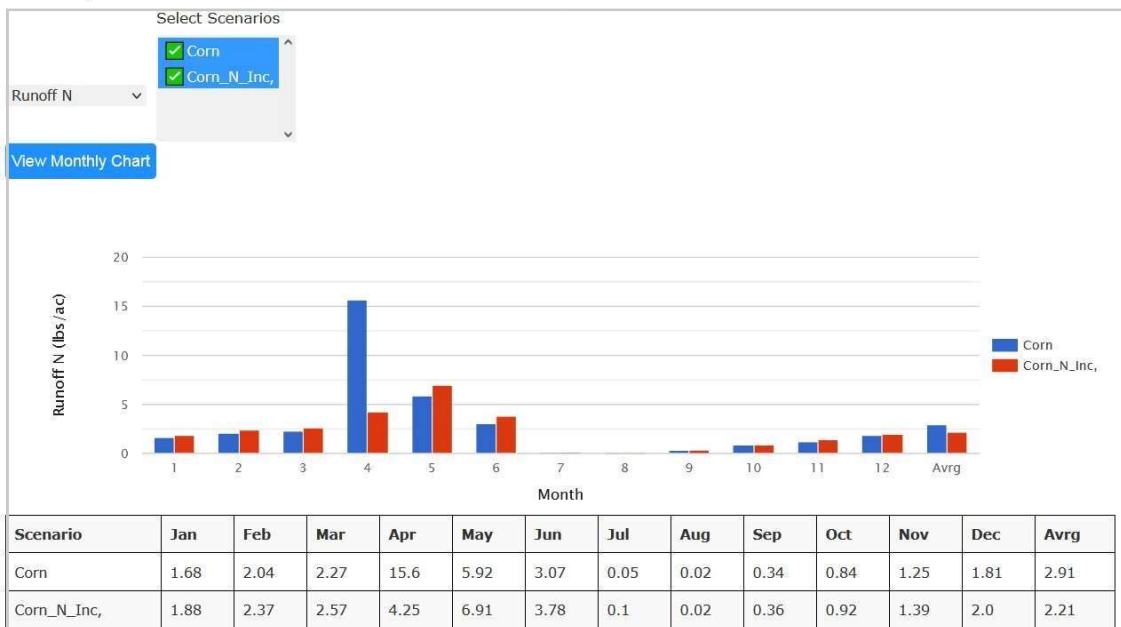

Figure 25: Graphic average monthly results in Results screen.

Field Routing (FR) / Watershed Scenarios

The FR/watershed feature allows users to simulate routing between fields. Alternately, users can use the FR function to simulate a watershed where, instead of fields, the AOIs represent subbasins. The user needs to select the field and scenario for routing. NTT program will automatically use the slope of selected field to route runoff, sediment, and nutrients from one field to the next (or from one sub-basin to the next if used to simulate a watershed) in the specified order. When viewing results, you may note that the load at the outlet of the watershed is less than the sum of the edge of field loads for each individually simulated field/sub-basin. This is because NTT simulates attenuation effects of water and nutrients as they flow over the landscape.

a) Create/Name Your Watershed

To begin creating a FR scenario, click Create New Watershed (Field Routing) to bring up a text box in which you type in the name of the scenario (Figure 26): After entering the name, click Save.
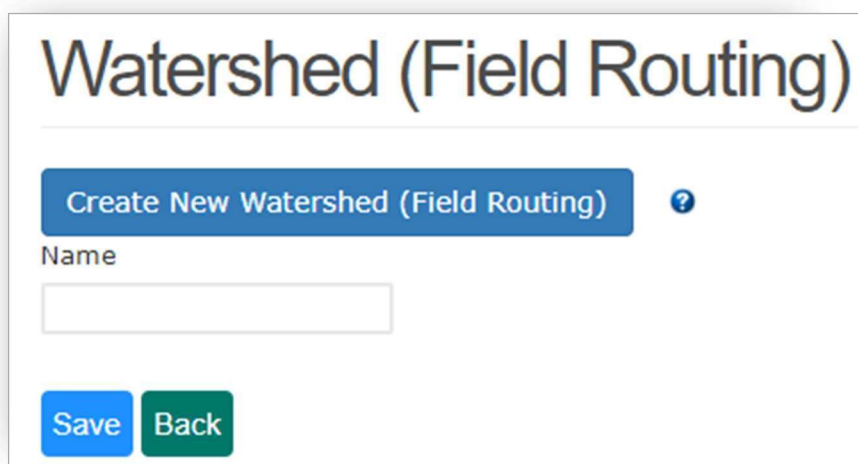

Figure 26: Creating New Watershed (Field Routing) in Watershed screen.

b) Build Watershed Scenario

On the Watershed (Field Routing) Page (Figure 27), the watershed name will appear in the list of watershed scenarios. Click the watershed scenario name to begin defining your watershed scenario.

When building your watershed scenario, begin adding fields/scenarios in the order that you wish to route the flow between fields. You may not add a field more than once to the same watershed scenario because the purpose is combining fields to simulate as one field. To add field/scenario combinations to the watershed scenario, select the field and scenario from the dropdown lists and click Add Field Scenario to the Watershed. Continue to add fields/scenarios until your watershed scenario list is complete. Once you have finished, click on the name of the watershed to close the pane.
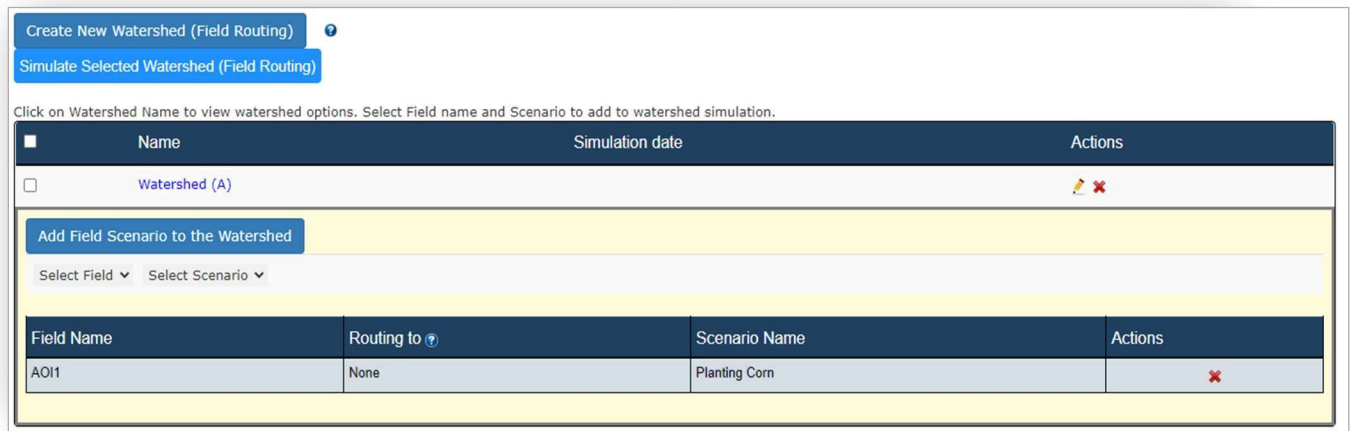
Figure 27: Field routing screen (expanded).

c) Manage Watershed Scenarios

The list of watershed scenarios you have created will appear on the Watershed (Field Routing) page (Figure 28). To begin defining your watershed scenario, or to edit a watershed scenario that you have already defined, click on the scenario name to begin defining/editing the scenario.

To delete your watershed scenario, click the delete ✖ icon.
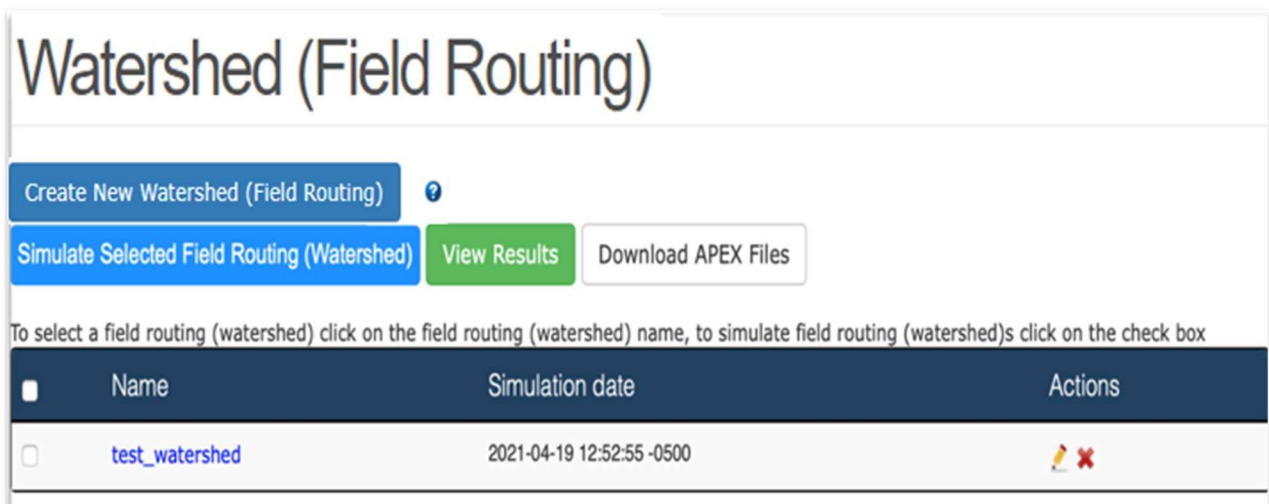To rename your watershed scenario, click the edit ✐ icon.

Figure 28: Field routing screen (collapsed).

d) Simulating/Viewing Results for Field Routing

To simulate a watershed scenario, select the name(s) of the watershed to stimulate and click Simulate Selected Field Routing (Watershed). Your watershed may take a few minutes to simulate. Once

simulation is complete, a simulation date/time will appear in the simulation date field next to the watershed scenario name.

To view results for field routings, select the scenario(s) you wish to view and click View Results. Results of Field Routing/Watershed scenarios are displayed in the same way that results are displayed for individual fields, including both tabular and graphical views.

NTT Farm Economic Model (FEM): User's Manual

NTT-FEM (Nutrient Tracking Tool – Farm Economic Model) is a user-friendly component of the NTT program that simulates economic costs and benefits of changes in farm management practices after the initial NTT model has been executed. The FEM model simulates entire representative farms holistically, so regardless of the size of the farm, the FEM model captures the full economic effect of the scenario. A set of representative farms is already included within the NTT-FEM program for this purpose. After economic simulations are completed by FEM, the output can be viewed in the NTT program.

The FEM results screen displays total revenue, total cost, and net returns. The FEM model estimates Total Revenue from crop sales by using the crop yield produced by the NTT model and the per unit crop selling price. Total Costs are estimated by FEM, using a wide array of subroutines, functions, and algorithms (Osei et al., 2000; for more information regarding FEM please refer to FEM technical documentation available in NTT program). For crop enterprises, the costs are estimated using various activities associated with crop production, such as land ownership costs, labor costs, machinery and equipment expenses, electricity charges, fuel prices, and fertilizer application costs. The third variable displayed in the results screen, Net Returns (also referred to as Net Income), is just the difference between Total Revenue to Total Cost. FEM also includes capabilities for simulating a wide spectrum of livestock operations.

a) The Economic Model Simulation

To estimate the economic effects of various crop management scenarios, users must select any scenario(s) by select the check box next to it, then click on the Economic & Water Quality Simulation tab to simulate both environmental and economic simulations. APEX must be run first in order to simulate the FEM program. The results obtained from APEX are used to evaluate economic impacts.

Figure 29: Three Scenarios Selected for economic model (FEM) simulation.

b) Economic Results

Figure 29 illustrates the selection of two scenarios to determine their economic effects for a Corn and Alfalfa crop rotation. The Economic results can be viewed by selecting the Economic Result (Figure 30) option in NTT main screen.

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Description	Planting Corn	Planting Alfalfa	
	Losses(±)	Losses(±)	Change(%)
Total Revenue ☑	922.51	0.00	-922.51 (-100.0)
Crop/Feed Sales	922.51	0.00	-922.51 (-100.0)
Livestock Sales	0.00	0.00	0.00 (NaN)
Total Cost ☑	1042.992	1080.03	37.04 (3.6)
Field Variable Cost	52.05	89.09	37.04 (71.2)
Overhead Cost	932.61	932.61	0.00 (0.0)
Other Cost	58.33	58.33	0.00 (0.0)
Net Results	-120.48	-1080.03	-959.55 (796.4)

Figure 30: Economic Impacts of Crop Management Scenarios on a Corn and Alfalfa Crop Rotation.

The first column in Figure 30 lists the categories of economic impacts associated with crop management options: Total Revenue (crop/feed and livestock sales), Total Cost, and Net Results. The remaining columns display the revenue from crop sales per acre (Total Revenue), the cost required to produce the crops in a unit acre of land (Total Cost), and the per acre net returns (Total Revenue minus Total Cost) for the baseline scenario and alternative scenarios.

The Economic Results page also provides Field Variable Cost that includes machinery variable costs, additional fertilizer costs, and field labor costs. Overhead Cost includes principle and interest payments, and depreciation and cost of equity capital. Other Costs include feed costs, facility maintenance costs, crop input costs, land lease costs, livestock purchase costs, manure hauling costs, and other costs depending on the farm type.

The economic costs, as described above, are estimated based on a national database developed by the NTT team at the Texas Institute for Applied Environmental Research (TIAER). However, since the specific economic input data varies from one location to another, NTT provides an option for users who wish to change certain input data to reflect their specific situations. Five tables are included in the "Economic Input Information" section of the NTT screen for editing input data. Users can change the values in each table as needed.

- The General Inputs table includes labor wages, land value, diesel and gasoline prices, and electricity price.
- The Commodity Prices table includes the purchase/selling price of feeds.
- The Equipment table includes equipment types and prices.
- The Facilities table presents the details of facilities used on the farm for various economic activities, such as barns, parlors, and feedlots.
- The Supplies table includes fertilizer and seed prices.

Figure 31 displays an example of the General Input Table available in the FEM model.

Figure 31: The economic "General Input" information

After modifications of any of the FEM input tables, users need to re-simulate the Economic & Water Quality models to see the effect of their modification(s).

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