Lease-Fallowing Water Accounting Tool

a.k.a. Lease Fallow Tool (LFT)

User Manual (Updated 1/26/2016)

Table of Contents

Introduction

This manual describes how to use the Lease-Fallowing Water Accounting Tool, or Lease Fallow Tool (LFT), which was developed to streamline and standardize the evaluation of the historic use of irrigation water and return flows to streams associated with land parcels in Colorado that may alter irrigation practices as part of a lease-fallowing project. This streamlined and standardized process is meant to facilitate evaluation of lease-fallowing scenarios that may provide an alternative to the practice of buying water rights and permanently removing irrigation water from cultivated land. The LFT was developed considering the Colorado HB13-1248[1] Criteria and Guidelines and is meant to be used to evaluate HB13-1248 lease-fallowing pilot projects. The LFT was also envisioned for lease-fallowing projects that could potentially be developed using means other than the HB13-1248 pilot project program.

The parcel water balance analysis of the LFT is based on the Irrigation System Analysis Model (ISAM)[2] which is patterned after the crop consumptive-use subroutine of the Hydrologic Institute Model (H-I Model or HIM)[3]. The version of ISAM applied in the LFT is implemented in the Mathworks MATLAB coding environment. The LFT interface is based in Microsoft Excel, and uses Visual Basic for Applications (VBA) code to interact with a compiled executable version of the ISAM MATLAB code. Scenarios can be developed by interacting with the Excel spreadsheets, and calculations are performed by the background code. Results are then displayed in Excel spreadsheets. The LFT requires Microsoft Office 2007 or newer.

The LFT is designed to operate in two general steps. As a first step, the "input" features of the LFT are used to create an input data page for every land parcel that is being evaluated for fallowing. The user selects options so that, when created, the input data pages are either filled with input data supplied with the LFT or left as a blank template in which the user can enter the required input data manually. The user can replace, modify or refine all input data in Excel.

---

[1] Colorado House Bill 13-1248 titled "Concerning An Authorization Of Pilot Projects For The Leasing Of Water For Municipal Use." charges and authorizes the Colorado Water Conservation Board (CWCB) in consultation with the State Engineer to develop Criteria and Guidelines to potentially administer several lease fallow pilot projects within Colorado. More information regarding the HB13-1248 can be found at:
http://www.leg.state.co.us/clics/clics2013a/csl.nsf/billcontainers/7DC007B50B310C9087257AF50061F594/$FILE/1248_enr.pdf
http://cwcb.state.co.us/water-management/water-projects-programs/Pages/Fallowing-LeasingPilotProjects.aspx

[2] The ISAM was decreed in Colorado Division 2 case 09CW110 as part of the Compact Rules Governing Improvements to Surface Water Irrigation Systems in the Arkansas River Basin in Colorado issued by the State Engineer. More information regarding ISAM can be found at:
http://water.state.co.us/SurfaceWater/RulemakingAndAdvising/ArkRiverAC/Pages/ArkSWIrrigImpRules.aspx
ftp://dwrftp.state.co.us/dwr/09CW0110/Models/ISAM/ISAM_Documentation.pdf

[3] The H-I Model was established and decreed in Kansas v. Colorado Supreme Court ruling (U.S. Original 105). More information at:
http://www.supremecourt.gov/SpecMastRpt/SpecMastRpt.aspx

During the second step, the "analysis" capability of the LFT is first used to simulate the historical water balance for a parcel using the data from the input page and a limited number of analysis options, and then to compute return flows to the stream for historic and altered conditions. A results page is created for all evaluated parcels. A set of summary tables also can be produced and arranged using a format that was developed by the LFT Technical Advisory Committee for the HB13-1248 Criteria and Guidelines potentially using a shorter study period for which return flows may be more representative of current conditions.

Input databases are supplied with the LFT to streamline and simplify evaluations using the LFT (although the user can also supply data). However, the user must apply diligence to ensure that all input data, whether supplied by the LFT or by the user, are appropriate. The LFT supplied data are derived from the Division of Water Resources Hydrobase database, regional Colorado Decision Support System (CDSS) related models which utilize Hydrobase data and the StateCU model, and data from the H-I model. The LFT is designed to be used with data from river basins throughout Colorado. However, the databases supplied with the current LFT version have been developed for the portion of Colorado Division of Water Resources Division 1 which encompasses the South Platte River Basin, Division 2 which encompasses the Arkansas River Basin (the current LFT includes climate based data for the entire basin but ditch specific data only for the Lower Arkansas Region), and Division 3 which encompasses the San Luis Valley. Work is ongoing to both expand data in the current databases (ie include CoAgMet station data and ditches in the Upper Arkansas Region) and develop databases for other areas of the state. The database files included with the current version of the LFT are named "LFTdb_CODiv1_v6.mat", "LFTdb_CODiv2_v6.mat", and "LFTdb_CODiv3_v6.mat"; it is envisioned that additional databases will be named with a similar format (eg. "LFTdb_CODiv4_v6.mat", etc). Users are able to select which databases they want to employ based upon the river basin of application. It is anticipated that the current databases will be updated on nearly a yearly basis, and users are able to replace older database versions with new versions through the internet using a button in the LFT spreadsheet. It also is envisioned that future versions of the LFT will be built to more directly access other databases, such as the Division of Water Resources Hydrobase database, and to more easily incorporate data from other database and model formats.

A Quick Start Guide follows that provides a brief summary of installing, preparing, and using the LFT. The second portion of this User Manual describes how to download and install both the LFT and the free Matlab Compiler Runtime program that is required to run it in more detail. The third portion of the manual describes the application of the LFT in more detail and the parameters that users are able to adjust.

Quick Start Guide

A listing of steps is listed below that should enable the user to install and begin to use the LFT. However, please refer to subsequent sections for more in-depth information.

Install the LFT

1. Click on the following link: http://water.state.co.us/DataMaps/ModelingCDSS/Pages/LeaseFallowTool.aspx
2. For a Windows computer download from the webpage either click on the "Install 32bit" or "Install 64bit" links depending on if your computer has a 32-bit or 64-bit version of Windows. Otherwise (or alternatively if an advanced user) skip to step 7.
3. Double-click on the downloaded file to begin the install program
4. Choose to install the LFT program at C:\LFT or some other folder that is <u>not</u> in Program files. **Important: Do NOT install to the default C:\Program Files\LFT location**
5. The program will download and install the free Matlab Compiler Runtime (MCR) R2014a on your computer at a location such as C:\Program Files\MATLAB
6. Go to the LFT application folder (ie C:\LFT\application) and double click LFTbatch_v6.bat
7. If Apple or Linux go to http://www.mathworks.com/products/compiler/mcr/index.html and download and install the appropriate R2014a MCR file and also follow the next step
8. From time to time the LFT may be updated. In that case, click on the links "Files 32bit" or "Files 64bit" from the webpage in step 1 and un-zip the downloaded file to the application folder (ie C:\LFT\application)

Prepare the LFT template

1. In the folder storing the LFT files, open "LFT_FarmDataTemplate_v6.xlsm". If the LFT was installed at C:\LFT, the file should be located at C:\LFT (or at C:\LFT\application).
2. Go to the "LFTfilename" worksheet and ensure that "LFT Folder:" (cell B1) contains the path to the location of the LFT executable (LFTengine_v4.exe). If you installed to the C:\LFT location then the default path "C:\LFT\application" should be correct.
3. At this point you may want to save the spreadsheet template to save the correct file path.

LFT Operations

1. To use the template spreadsheet for a parcel analysis, it is recommended to save the spreadsheet with a different name and to the most appropriate folder for the project.
2. If prompted by Excel, you must choose to enable macros. The user may want to select to always enable macros in Excel to avoid future prompts.
3. Go to the "LFTparcels" worksheet. Cell comments give brief descriptions of most options.
4. Overall parcel naming and control is managed in the red section. Multiple parcels or scenarios can be evaluated using multiple rows in the "LFTparcels" worksheet. Click on the "Add Row" button to add additional parcel rows. Buttons to the right of the "Add Row" button will only operate on parcels with the "Control On/Off" option set to "ON"

5. The building and manipulation of input data is managed in the blue section. Work from left to right to select all options from the pull down lists. In the "Dataset" column, selection of "HB1248" will produce input data using the HB13-1248 criteria and guidelines. When the "Build Input Data Pages" button is pressed, input data pages will be built for all parcel rows that are "ON". The user will be prompted to overwrite, etc, if the input pages already exist.

6. Input data pages are named "*Parcel ID*_data". The user can either manually copy data from another location and paste it into the appropriate locations in the data pages or select the "User Data" button to select data from other Excel based files. At a minimum the user should enter parcel acreages and ditch share information (if available). On the input data pages, entries do not need to be repeated; rather an entry value can be entered once and that entry value will be used for all subsequent years until a new entry value is encountered.

7. In the input data pages, the user may want to alter the crop distribution in which case the "Update PET for Crop Dist" button can then be pressed to update the ditchwide PET.

8. Parcel analysis and summary table options are managed in the orange section. Some default options are picked and other options are optional. Often, a study period is picked that is smaller than the period of record picked for the input data pages. Refer to cell comments or later sections of this document for additional option information. Once options are selected, press the "Run LFT Analysis" button and both results "*Parcel ID*_R" and summary "*Parcel ID*_S" pages will be produced for every parcel that is evaluated.

9. Hyperlinks (in blue) are placed in the aqua colored sections and when selected the chosen input, results, or summary page is opened. Hyperlinks are also available in the results and summary pages to quickly jump to table locations within the pages. Changing page names will break the links, but otherwise pressing the F9 key may fix links if they stop working.

10. The results pages contain data for most variables over the entire period of the input data pages. The summary pages contain selected tables that are formatted for display and printing. Through print setup, margins and page sizing can be selected so that tables are printed separately on only one or two pages.

Setup Walkthrough

To obtain the LFT installation files

1. If the LFT files already have been obtained, skip these steps; otherwise
2. Copy and paste the following link to your web browser or windows explorer:
   http://water.state.co.us/DataMaps/ModelingCDSS/Pages/LeaseFallowTool.aspx
   This page can be accessed by going to Colorado Division of Water Resources website (water.state.co.us), selecting Data&Maps, Modeling/CDSS, and the Lease Fallow Tool tab. An alternate link is from the CWCB website (cwcb.state.co.us) Technical Resources tab at:
   http://cwcb.state.co.us/water-management/water-projects-programs/Pages/LeaseFallowTool.aspx
   The web page shown in Figure 1, or something similar, should be shown

Figure 1. Image of CDWR LFT webpage with links for Matlab MCR, installation files, and LFT zip-files for 32-bit or 64-bit operating systems.

Alternative 1 – Installation with Install Files

3. Click on the appropriate "Install" link to download either the "LFT_install_w32bit.exe" or "LFT_install_w64bit.exe" file from the website site depending on if your computer has a 32-bit or 64-bit version of Windows
   3.1. *How to determine if you have the 64-bit version of Windows*

      3.1.1. For Windows 7 - Click the Start icon , then right-click "Computer" and select "Properties". The windows version will be displayed next to *System type*.
      3.1.2. For Windows XP - Click the Start Menu, select "Settings", and then select "Control Panel". Select "System", and then click on the *General* tab. Examine the information under "System". If there is nothing listed "x64 edition version" or "64-bit Operating System", then you have the 32-bit version

4. Select and run (e.g. double-click) the downloaded "LFT_install_w**bit.exe" file. An install program will run to install the files.
   You must have both administrative privileges and have access to the internet to install this version of the LFT. If you are not logged in as an administrator, you may be able to right click on the file and select "run as" to run as an administrator.

5. The install file will download and install the Matlab Compiler Runtime (MCR) R2014a on your computer, if not already installed.
   5.1. *By default the MCR program will be installed under **C:\Program Files\MATLAB***
   5.2. *Why do I need the MCR?* The MATLAB Compiler Runtime is free software that allows a computer to run a MATLAB executable, like the one implemented by the LFT, without requiring a MATLAB license. The MCR consists of a library of files needed to run the executable.
   5.3. *Do I need to install the MCR if my computer already has MATLAB installed*? The current LFT version was compiled under MATLAB version R2014a. If you have MATLAB version R2014a you will not need to install the MCR, but if you do not you will need to also install the R2014a MCR in order for the LFT files to run.
   5.4. *By default the MCR program will be installed under C:\Program Files\MATLAB.*

6. The install file will also install the Lease Fallow Tool files on your computer.
   Important: When installing the LFT program, DO NOT INSTALL to the default location at C:\Program Files\LFT. It is recommended to install the files at C:\LFT or some other folder that can be dedicated to the LFT (the LFT must be able to write to this folder and files cannot be written to Program Files in Windows 7-on)

7. Optional: Run batch command to copy files to a common folder and potentially improve LFT efficiency.

7.1. In Windows Explorer (press the "Windows" key and "E" together) navigate to the "application" folder in the LFT install folder (ie C:\LFT\application) and run the LFTbatch_v4.bat batch file (ie double click on the file).

7.1.1. *The batch file copies the LFT spreadsheet template to C:\LFT for use.*

7.1.2. *The batch file also issues a command so that some files for the MCR are copied to C:\LFT\MCR. This speeds up operation for the first LFT run after each time Windows is restarted. However, refinement is needed as this command does not yet work on all systems. Therefore, manually performing this operation may be needed as described in the next optional step.*

8. Optional: To ensure performance, manually check windows environment variables and manually add if the variables were not added by the batch program.

8.1. For Windows XP – right click the "My Computer" icon on the desktop and select "Properties". In System Properties go to the *Advanced* tab and select "Environment Variables".

8.2. For Windows 7 - At the Start menu, select the "Control Panel". Under Control Panel select "System and Security", select "System", then in menu on left select "Advanced system setting". Under the *Advanced* tab, select the "Environment Variables" button.

8.3. If the "User Variables" or "System Variables" do not include an MCR_CACHE_ROOT entry then under user variables (system variables if an administrator) select "New" and enter "Variable Name": MCR_CACHE_ROOT and "Variable Value": C:\LFT\MCR and select OK. Figure 2 displays these menus for Windows XP and Windows 7.
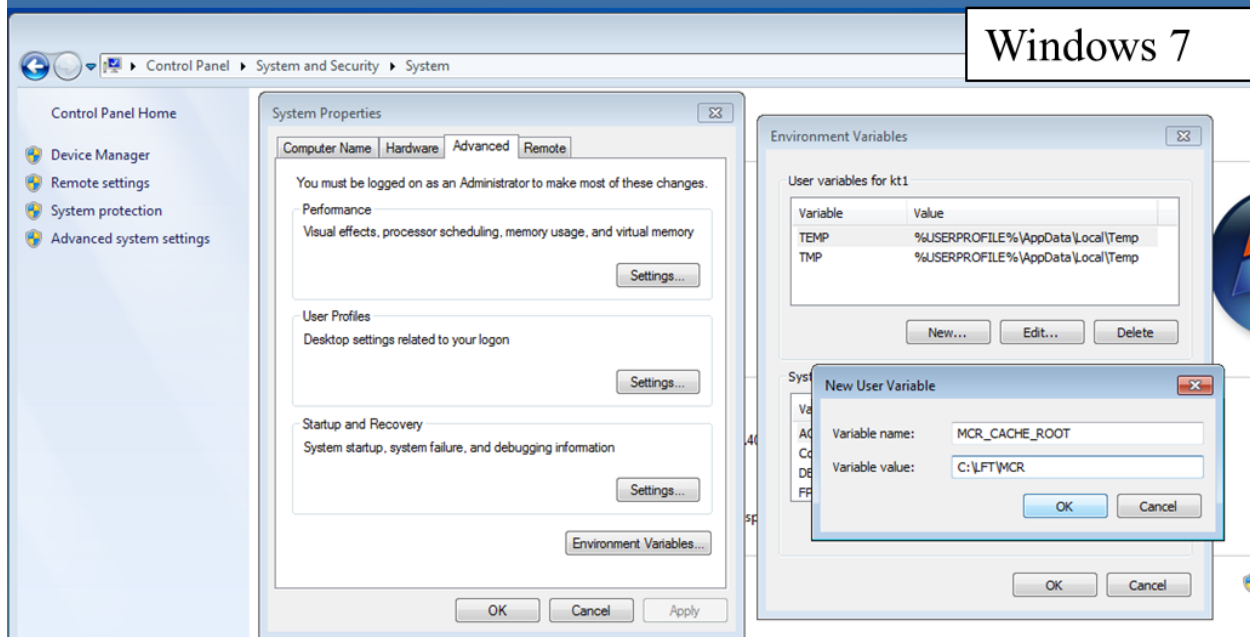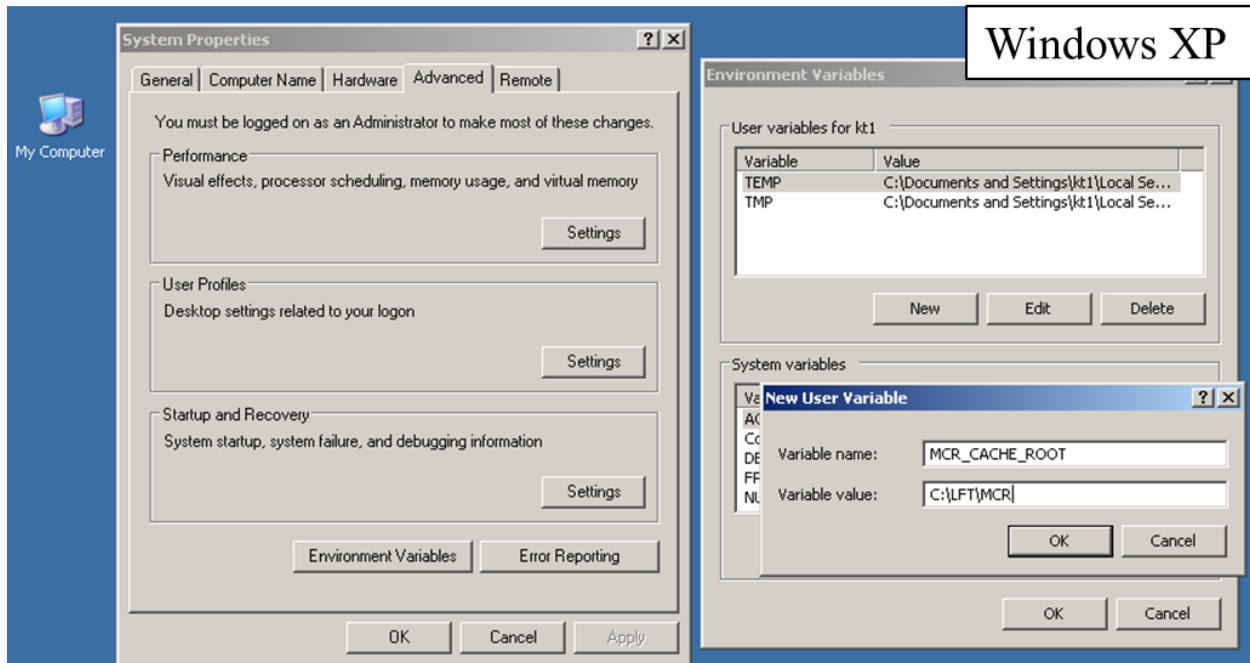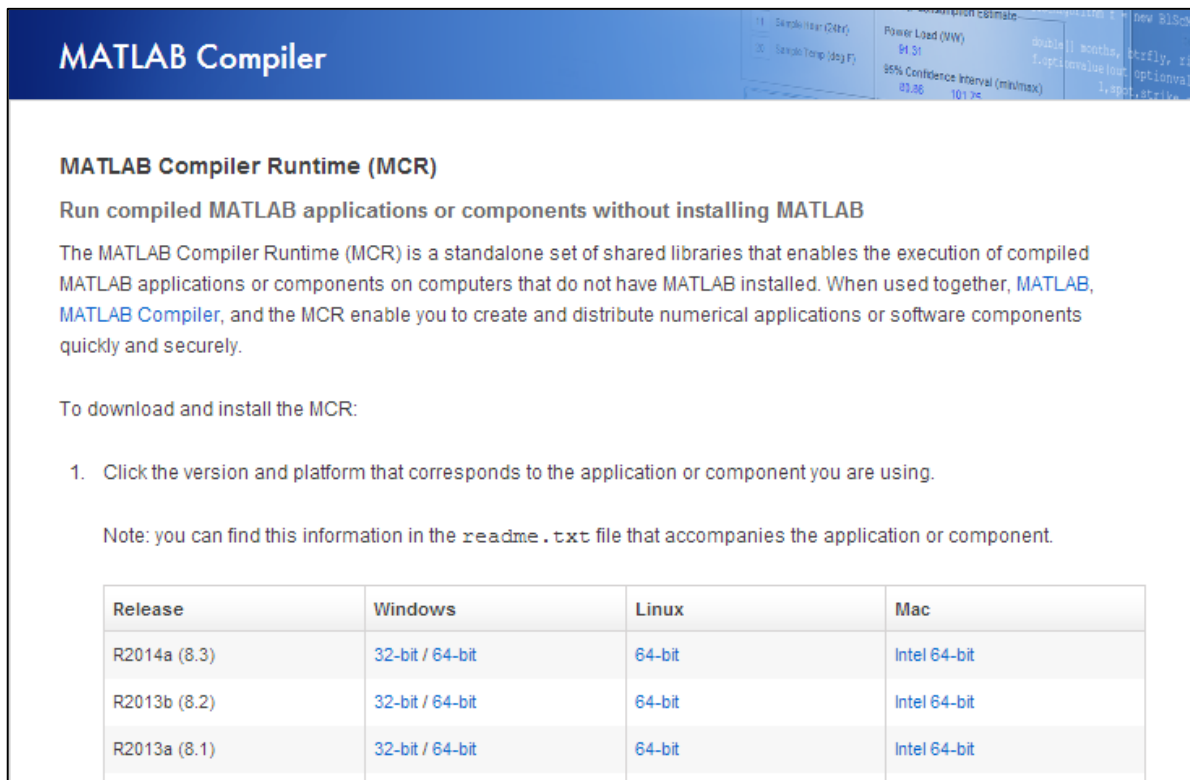
Figure 2. Screenshots showing the process of checking the Windows environment variables and manually adding the variables if they were not added automatically by the batch program. The top image displays the process for Windows XP operating systems, and the bottom for Windows 7.

Alternative 2 – Install the files separately (recommended for advanced users)

1. You also can perform manual installations of the MATLAB Compiler Runtime (MCR) and use the LFT executables directly. If the R2014a MCR has already been installed (if, for example, you installed an earlier version of the LFT and are updating to a newer version), skip to step three as the MCR will not need to be reinstalled.
2. Download and install the MCR[4].
   2.1. Go to the following webpage (Figure 3) to begin MCR installation:
   http://www.mathworks.com/products/compiler/mcr/index.html

Figure 3. Screenshot of the Mathworks website where the user can download the MATLAB Compiler Runtime (MCR) program. Options are available for 32-bit and 64-bit operating systems.

3. Find the row for Release **R2014a (8.3)** and select 32-bit or 64-bit based on the computer you are using. The MCRs are available for Linux and Apple Macintosh computers, but the LFT executable has been tested only on Windows XP and Windows 7.

---

[4] *Questions about the MCR?* See items 3.1 and 3.2 in the preceding section.

3.1. *See the previous steps on obtaining the LFT files to determine whether your computer uses the 32-bit or 64-bit version of Windows.*

3.2. Follow the steps prescribed on the webpage to successfully install the MCR.

4. Using the "Files" link on the DWR or CWCB LFT webpages described earlier, download "LFT_files_w32bit.zip" or "LFT_files_w64bit.zip" depending on your computer. Unzip to a folder dedicated to the LFT. If a previous version of the LFT was installed, you can copy files to the same location and some files may be overwritten. Using an installation folder as recommended in the previous section, the LFT files would be copied into the **C:\LFT\application** folder.

Installation Complete message

Following successful installation, the program will present the user with the following message:

"Thank you for installing the LFT!

Although the Matlab MCR can be installed to the default folder, do not install the LFT files in the default location in "Program Files". An alternate folder such as C:\LFT must be used.

Following installation, it is recommended to run the batch program LFTbatch_v6.bat located at C:\LFT\application\ (or application folder at location chosen for install)

The .bat will copy the Farm Data Template and Users Manual to C:\LFT and attempt to set up an MCR system folder that may help improve performance.

Please direct any issues with the LFT to Kelley Thompson at kelley.thompson@state.co.us"

Operation of LFT

To begin setting up a new scenario
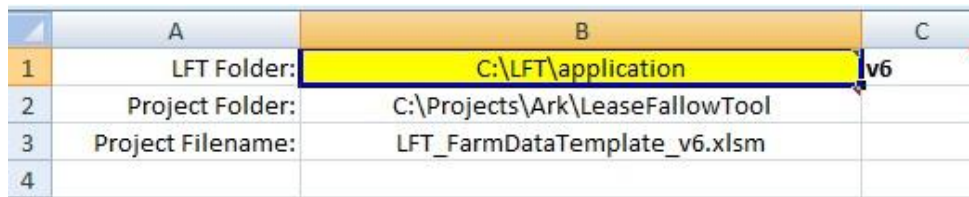
1. In the folder storing the LFT files, open "LFT_FarmDataTemplate_v6.xlsm". If the LFT was installed at C:\LFT, the file should be located at C:\LFT (or at C:\LFT\application if the batch program was not run)

   1.1. The LFT utilizes VBA code based in Excel, so it is important to enable macros if Excel displays a prompt. You can set Excel to enable macro files without prompting if desired.

   1.2. It is recommended to leave an original copy of the blank "Farm Data Template" in its original location (C:\LFT\application). However, users can save the "Farm Data Template" and applied versions of the spreadsheet after parcel data have been entered using a different name and in a different location for organization or convenience as long at the correct file paths are specified in the spreadsheet (described below).

2. The following steps outline each tab in the "Farm Data Template" and the user-controlled options found in each

Comments embedded in the "Farm Data Template" give brief descriptions of most spreadsheet cells (hover over the red arrows to view them).

LFTfilename worksheet

User-Specified Install Folder Setup

1. If you installed the LFT using the web install program and specified the LFT install location as "C:\LFT" you should be able to skip this section.
2. The "LFT Folder" cell (B1) in the "LFTfilename" worksheet (Figure 4) that is shaded yellow contains the file path that leads to the location of the LFT executable (LFTengine_v6.exe) and database files (LFTdb_CODiv*_v6.mat) on your computer. Enter the location of the folder with these files in this cells; the correct file path is required for the LFT to run. If you installed the LFT using the web install program and specified the LFT install location as "C:\LFT", the folder location of "C:\LFT\application" should correctly identify the location of LFT executable and database files.
3. You should not need to adjust any other cell in this worksheet. The "Project Folder" (B2) and "Project Filename" (B3) cells can be adjusted manually, but should automatically update based on the filename and location of the open project spreadsheet. If these cells do not update automatically, pressing the "F9" key typically will cause them to update correctly or they can be entered manually.

	A	B	C
1	LFT Folder:	C:\LFT\application	v6
2	Project Folder:	C:\Projects\Ark\LeaseFallowTool	
3	Project Filename:	LFT_FarmDataTemplate_v6.xlsm	
4			

Figure 4. Screenshot of the "LFTfilename" worksheet where the user must specify the location of the LFT executable file

4. The LFT version number cell (C1) identifies the appropriate LFT executable. It is possible that at some point the user may which to change this to a different version in order to a project spreadsheet with an updated version of the LFT. However, this would only be possible if a new version remains compatible with the spreadsheet which is not guaranteed.
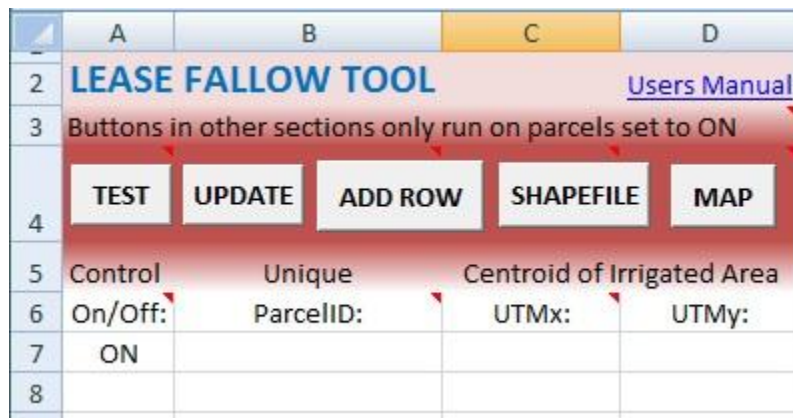
LFTparcels worksheet

1. Parcel Options

The "LFTparcels" worksheet (Figure 5) serves as the main interface to set up and run lease-fallowing scenarios. Each row of data that is filled, starting at Row 7, can represent either an additional land parcel for analysis or a different scenario for parcel analysis. To build a parcel analysis, work sequentially through each colored section, potentially selecting a grey button within that section to act upon data. The following instructions for the worksheet are organized by each sequential colored section.

    1.1. A link is provided to open the "LFT User Manual" at the top right hand corner of the control option section (first dark-red colored section).

> *This hyperlink is dependent upon the LFT file location specified in the "LFTfilename" worksheet. If not working, pressing the "F9" key may correct the link.*

Figure 5. Section of the "LFTparcels" worksheet used to specify the name of each farm parcel to be analyzed, as well as to enter the UTM coordinates of the parcel for use in climate dataset selection.

    1.2. **TEST** Button

This button will test the file paths specified on the "LFTfilename" worksheet to ensure that the LFT executable and database are in the location specified by the user.

    1.3. **UPDATE** Button

This button will check if new LFT database files are available and, if they are, will ask the user if the LFT can update these files. The current LFT message will also be opened a browser

or that will inform the user if new versions of the LFT executable, spreadsheet, or other files are available. Although the LFT can update the database files, the user will have to manually replace other files that are updated. Updating files is described more in item 4 in the previous Section titled. "Alternative 2 – Install the files separately".

1.4. **ADD ROW** Button

Multiple parcels can be evaluated for fallowing using multiple rows in the "LFTparcels" worksheet. Generally, a farm consists of several smaller parcels, which are also called fields. If the user desires to evaluate additional parcels, or the same parcel in a different way, the "Add Row" button can be used to copy the previous parcel evaluation to the next row, or the user can manually copy completed parcel control data to the next row. This button also will create the necessary drop-down lists in each cell, which are required to set up new scenarios. This action is performed by Excel VBA rather than by the compiled executable. Users also can manually select a desired row by clicking on row the number, selecting "Copy", and pasting to the row at the bottom of the list.

1.5. **MAKE SHAPEFILE** Button

An ArcGIS shapefile containing the locations of each parcel lease fallowing scenario for which UTM coordinates are provided can be created by selecting this button. Only scenarios that are switched "ON" (see "Control On/Off" column) will be included in the shapefile. Each location will be expressed as a point in the ArcGIS shapefile.

1.6. **MAP** Button

A map, displayed within a new window, can be created which displays the location of each scenario to ensure that the centroids of parcels and climate stations are correctly entered or selected. The map will include areas irrigated by a ditch (if a ditch is selected and data are available), the ditch headgate (in blue), nearby climate stations (in black), and selected climate stations (in red). The code performing this function relies on UTM coordinates, the selected ditch (or canal), and the selected climate station. Therefore, users will need to complete the following "Input Data Options" section before initializing this feature.

2. Control Options

These options control analysis and parcel or scenario naming convention

- "Control On/Off" column
  - "ON" is selected if the user wants the LFT to run operations for that scenario on the selected row or parcel

o "OFF" is selected if the user does not want operations performed for that scenario on the selected row or parcel

Buttons pressed in the subsequent colored sections will only operate upon the parcels with "ON" designated under "Control On/Off". This option gives user the flexibility to run some scenarios while leaving others unchanged.

- "Unique ParcelID" column

This establishes a user-defined name for the scenario. These names should be unique, as the LFT will create data, results, and summary table worksheets using this name. *ParcelIDs should not exceed 27 characters.*

- Centroid of Irrigated Parcel to be Fallowed

Users are able to specify the UTM coordinates associated with the centroid of the parcel under consideration. Coordinates can be used by the LFT to choose the nearest station for climate data, and can be used by the mapping features, as explained below. If no coordinates are entered or coordinates map 100 miles from the nearest climate station, the centroid of the irrigated area of the selected ditch will be used to determine the climate station.

3. Input Data Options

The "Input Data Options" section of the "LFTparcels" worksheet is used to specify input parameters for each parcel to be analyzed. The user can select the Colorado region in which the parcel is located, which dataset should be used, and various other data pertaining to irrigation and climate variables.

3.1. **BUILD INPUT DATA PAGES** Button

Each scenario that has been established following the previous steps will require a data page to run the LFT analysis. The "Build Input Data Pages" button (Figure 6) initiates a VBA macro that will save the entire spreadsheet, save a .csv file listing file locations to the LFT folder, and call the MATLAB executable in order to build the input data worksheets. A message box will appear when the code initiates.
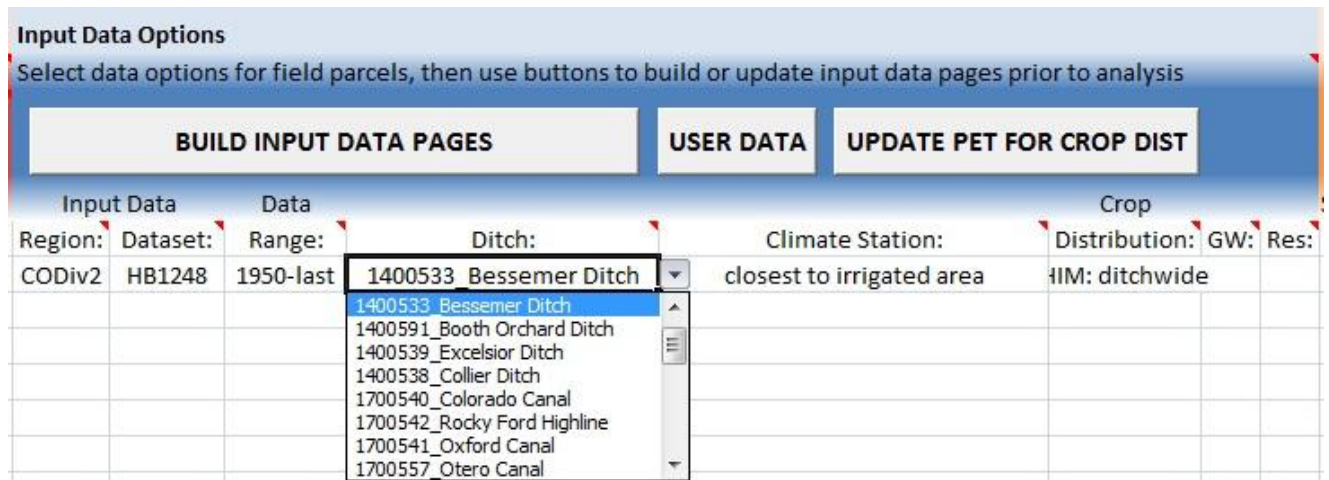
Figure 6. Input Data Options section of the LFTparcels worksheet. Here the user can enter the region in which each parcel is located, the dataset used for analysis, the years over which the data is analysis is performed, and the ditch from which the land parcel receives water. The climate station, depending on which dataset is selected, will either default to "closest to irrigated area" or can be user-specified. Crop distribution can also be specified. Optional pulldowns allow entry of groundwater diversion amounts or number of off channel reservoirs. An example drop-down menu also is shown, used for selecting which ditch is to be used for analysis.

Once this button is selected, a new worksheet is added to the .xlsm file for each of the lease-fallowing parcels listed. The new worksheets are titled according to each "Parcel ID" listed in the "Unique ParcelID" column (e.g. "*Parcel ID*_data"). Each worksheet is populated using the data from the database unique to that "Parcel ID" as it can be determined from each run selected in the "LFTparcels" worksheet. The user can review the raw data worksheets, add, or edit as desired.

If it is desired to evaluate similar parcels or scenarios, the user also can copy a data page that is already populated, change the name of this new worksheet (e.g. "*Parcel ID new_data*"), and enter a new row in the "LFTparcels" worksheet for the new "Unique ParcelID".

After the user has finalized the data in "Parcel ID_data" worksheet, the user should return to LFT parcels worksheet.

3.2. **UPDATE PET FOR CROP DIST** Button

The LFT analysis utilizes ditch-wide potential evapotranspiration (PET) and precipitation as input. Ditch-wide PET is calculated from the crop distribution and crop-specific PET values when input data pages are created, with crop distribution representing the fraction of each parcel dedicated to various crop types. However, if the user changes the crop distribution for a parcel or supplies different crop-specific PET values (e.g. estimated using an alternate method), the ditch-wide PET should be recalculated using this button.

Monthly crop specific PET values are listed furthest to the right within the data on the "_data" page. Below the crop PET time series, an additional row is entered that is titled "Mult:" and initially the default values of these multiplicative factors is equal "1.0". Monthly crop specific PET values are multiplied by these multiplicative factors when ditch-wide PET is calculated, for use in calibrating or adjusting monthly PET values.

A block of data is also provided that approximates potential non-growing season demand due to soil evaporation and stubble transpiration using the same method as used for the H-I Model. The multiplicative factors for this demand is initially set to zero, but the demand can be included if the factors are set to "1.0" and the PET is updated using the button.

3.3. **USER DATA** Button

The "User Data" button allows the user to import data from an external spreadsheet into the input data page. Data can include PET, climate, or crop distribution, and should be an Excel-based file of monthly value for each year of the selected data range.

3.4. Selection of Input Data

Each parcel scenario to be analyzed must have an input data page (e.g. "UniqueParcelID_data"). The user can supply input data to evaluate with the LFT. However, databases are available to streamline the input of data directly into the LFT. These data are produced from the CDSS/DWR Hydrobase database, CDSS related models that utilize Hydrobase data within the StateCU model, or from the H-I model specific to Division of Water Resources Division 2 (CODiv2). The LFT is designed for application throughout Colorado, but initial data have been developed for CODiv1, CODiv2, and CODiv3, encompassing the South Platte River Basin, Arkansas River Basin and San Luis Valley (Upper Rio Grande Valley in Colorado), respectively. Therefore, the following descriptions focus on options specific to these divisions.

The options selected by the user in the "Input Data Options" section specify which data will be used to build input data pages for each selected parcel. These options are described below.

- "Region" column

This option specifies the DWR Division in which the parcel being analyzed is located. This determines which options will be available in the following columns. Currently, only CODiv1, CODiv2 and CODiv3 are available. Subsequent column options will not become available until a region is selected.

- "Dataset" column

This column specifies the name of one input dataset to be utilized, which determines which options will be available in the following columns. A description of the data sets available for the

Arkansas River Basin is found below. A diagram depicting options available with each dataset is provided in the Appendix. Subsequent column options will not become available until a dataset is selected.

- "HB1248"

    Selecting "HB1248" will allow import of ditch constants and climate station data using the HB13-1248 Criteria and Guidelines which was developed by the Colorado Water Conservation Board (CWCB), Colorado Division of Water Resources (CDWR), and a technical advisory group which included engineers, water users, and attorneys. Ditch constants are derived from CDSS models or the Division 2 H-I Model. Those constants are changed in the HB1248 case such that on-farm lateral losses are set to 0, irrigation application efficiencies set to 55%, total available root zone soil moisture storage limited to 6 inches, surface runoff assumed to be 20% of total return flows, and PET calculated using the Modified Blaney-Criddle method with USDA Conservation Service Technical Report 21 (TR21) crop coefficients (TR21 crop coefficients are crop factors specific to the Blaney-Criddle method of estimating evapotranspiration). The climate station is expected to be the closest climate station to the irrigated parcel and crop distributions are assumed either as ditch-wide distributions from the HI model, from regional CDSS models, or from county statistics on crop distributions. Only one climate station is used for PET and precipitation.

- "MBCTR21"

    The "MBCTR21" option will import PET data calculated using the Modified Blaney-Criddle method with TR21 crop coefficients. As in the "HB1248" option, data from only one climate station are used for PET and precipitation calculations. However, model parameters for on-farm lateral loss, application efficiencies, and soil moisture are imported (from the H-I Model for CODiv2 and from CDSS models for other divisions) and return flow portions are maintained as calculated. For the "MBCTR21" option, the user also is able to select different National Oceanic and Atmospheric Administration (NOAA) climate stations from a list of available stations.

- "DSS"

    The "DSS" option is available for Division 3 and will import PET data calculated using the Modified Blaney-Criddle method with calibrated crop coefficients. Please refer to DSS documentation that describes the calibration of crop coefficients. Similar to the "MBCTR21" option, data from only one climate station are used for PET and precipitation calculations, model parameters are taken from the CDSS models, and return flow portions are maintained as calculated. The user also is able to select different National Oceanic and Atmospheric Administration (NOAA) climate stations from a list of available stations.

o "HIM"

This option is available within CODiv2 and limited to the H-I Model study area. The "HIM" option will import the ditch-wide PET and precipitation data from accepted HI model data. PET is calculated from the ASCE standardized method using Colorado Agricultural and Meteorological (CoAgMet) station data (if available). PET for years prior to the installation of the CoAgMet stations are based on calibrated Modified Blaney-Criddle calculations using data from National Oceanic and Atmospheric Administration (NOAA) stations. The calibration used data years when both CoAgMet and NOAA data was available. Precipitation data generally are from NOAA stations. The HI model ditch-wide PET is based on a weighting of values calculated using data from multiple climate stations using a procedure accepted for use in the HI model. However, PET at individual CoAgMet station locations also can be selected.

- "Data Range" column

The selected date range defines which years and data time series are included on each parcel "_data" page. The default ranges listed represent either 1) the range of data that are available in the LFT database or 2) a common period that is often evaluated (e.g. from 1950). The word "last" means that the period will extend through the period of data available in the LFT. If the "enter" option is selected, the user will be prompted to enter a user-defined data range for that parcel when the "Build Input Data Pages" button is selected. If the user enters values outside of the range of data available in the LFT database, the specified years will be entered in the input "_data" page, with blanks left in those sections of the page that need to be filled by the user. If an LFT analysis is run with missing data in the input "_data" page, the LFT will prompt the user to fill portions of the data with averages.

- "Ditch" column

The ditch column allows for the selection of ditch data that currently are contained in the LFT database, arranged by their name and by the Colorado Division of Water Resources HydroBase reference number (WDID). If the user is interested in a ditch for which no data are present in the LFT, the "Build Blank Template" option can be selected, and the user can enter data directly into the " _data" worksheet after the data pages are constructed.

- "Climate Station" column

When the "HB1248" dataset is not selected, users are able to specify a NOAA or CoAgMet weather station other than the one automatically selected by the LFT. The drop-down menu includes stations and their corresponding ID numbers that are contained within the LFT database. For the "MBCTR21" and "HB1248" dataset options, the LFT also can select the nearest climate station based either upon the irrigated parcel centroids, if provided, or upon the centroid of the selected ditch's irrigated command area. For the "HIM" dataset, the LFT also can select the

approved ditch-wide PET and precipitation that were calculated using an approved ditch-wide weighting of several climate stations.

- "Crop Distribution" column

For CODiv2, users are able to select the available HI model ditch-wide crop distributions or county-based crop distributions for the calculation of PET. The user also can select the "blank_(grass)" option to accommodate entry of user-supplied data directly into the "_data" worksheet after the data pages are constructed. In this case, the distribution initially will be input as entirely grass pasture as this is common in many non- HI model ditches.

Analysis and Summary Table Options
Select options to use in analysis and for summary tables, then use button to run

RUN LFT ANALYSIS

Study Period for Tables		Soil Moisture		Volumetric		Lag	Effective Precip Options		Extra
BegYear:	EndYear:	Initial:	Wrap:	Limits:	CumLimits:	On/Off:	PartialMonth:	Excess:	SheetID:
1980	2010	0.1	study period	Max3	Max10yr	OFF	no-ISAM/HI	yes-ISAM/HI	

Figure 7. Screenshot of the "Analysis and Summary Table Options" section of the "LFTparcels" worksheet. Information in this section is used to control the analysis to simulate the historical water balance using data from the input page.

4. Analysis and Summary Table Options

The "Analysis and Summary Table Options" (Figure 7) controls the analysis to simulate the historical water balance for a parcel using the data from the input page. A results page is created for all evaluated parcels, and options also control the optional summary tables that can be produced.

- "BegYear" and "EndYear" columns

The simulation as represented in the results worksheet will consider all years of data in the "_data" worksheet. However, values in the "BegYear" and "EndYear" columns can be used to limit the study period for the formatted summary tables. Statistics in the summary tables such as average; minimum, and maximum values; depletions factors; and return flow factors will be provided only for the summary period. If the entire study period is to be considered, users can leave the "BegYear" and "EndYear" columns blank. If a zero is entered in the "BegYear" column then the summary tables will not be produced.

- "Soil Moisture - Initial" column

The entry in this column governs how soil moisture is initialized for the first month of the analysis in the model. Note that for the "HB1248" dataset option only the value 0.1 is listed for the volumetric fraction of soil moisture while a different value can be listed when other datasets are selected. The initial soil moisture generally corresponds to the year range listed in the "_data" worksheet, rather than to the potentially smaller annual range used for the summary pages and statistics. With the "HB1248" dataset selected, only the "0.1" option is available. For other datasets the options available are:

- o "0.1"

  By default, initial soil moisture will be set to 0.1 which is the fraction of soil moisture volume to total soil volume, as is done in the HI model for year 1950.

- o "enter"

  The "enter" option is available only when the user has not specified "HB1248" as the dataset to be used for analysis. When selected, the LFT will prompt the user to enter a value for each parcel. The value entered is the decimal fraction of AWC and the initial default value is 0.5. Note that the entered value is a different measure than the measure noted above and the model will multiply this fraction by the AWC (expressed as a volumetric fraction) to determine the initial percent soil moisture as a volumetric fraction (as above) and multiply this percent by the rooting depth and area to determine soil moisture in acre-feet.

- • "Soil Moisture – Wrap" column

Soil moisture wrapping consists of simulating soil moisture values from the beginning of the study period to a specified end date, and then using the soil moisture content at the end date as the initial soil moisture condition when the simulation is restarted. Final results from the second run of the simulation will be displayed. When a soil moisture wrap is selected, delayed return flows to the stream remaining at the end date also will be wrapped to the beginning year specified on the input data page (but not necessarily to the beginning of the study period, if different). This wrap of delayed return flows is only applicable when "Lag On/Off" = ON.

- o "none" option

  No wrapping will take place; the simulation will begin with specified initial soil moisture content for the first year in the study period.

- o "study period" option

  When this option is selected, the ending soil moisture after the last year of the study period (as specified in the "EndYear" column) from the initial simulation run will be wrapped back as the initial soil moisture for both the first year on the input data page and

the first year of the study period (as specified in the "BegYear" column) for the second analysis simulation run.

- o "full period" option

    When this option is selected, the ending soil moisture after the last year on the input "_data" page from the initial simulation run will be wrapped back as the initial soil moisture for the first year on the input data page if the user wishes to perform a second analysis simulation.

- o "enter" option

    When this option is selected, the user will be prompted to enter the first year and end year to define the years for the initial soil moisture to be wrapped (similar to "study period" option)

- "Volumetric Limits" column

This option selects the volumetric limitations (e.g. the maximum values allowed for some variables) that are applied when creating the simulation tables ("Transferrable Depletions Given Calculated On-Farm Depletion Factors" and "Transferrable Depletions Given Calculated Stream Depletion Factors" summary tables); and potential volumetric limits are calculated and reported in the summary tables for 1) diversions, 2) farm headgate deliveries, 3) consumptive use, 4) farm headgate depletions, 5) delayed return flow to the river, and 6) stream depletions. These values could be used for operational limits for future administration of the subject water rights. With the "HB1248" dataset selected, only the "Max3" option is available. For other datasets the options available are:

- o "Max" option

    The maximum value for each calendar month over the study period is selected and displayed in the summary tables and used for simulation.

- o "Max3" option

    An arithmetic mean of the largest three values for each calendar month over the study period is calculated and displayed in the summary tables and used for simulation.

- o "Maxyear" option

    The maximum annual value within the study period and the monthly value for each month within that year is determined and displayed in the summary tables and used for simulation.

- o "Meanstd" option

The arithmetic mean plus one standard deviation is calculated for each calendar month over the study period and displayed in the summary tables and used for simulation.

o "Mean" option

The arithmetic mean is calculated for each calendar month over the study period and displayed in the summary tables and used for simulation.

- Volumetric CumLimits" column

This option selects cumulative volumetric limitations that are applied when creating the simulation tables ("Transferrable Depletions Given Calculated On-Farm Depletion Factors" and "Transferrable Depletions Given Calculated Stream Depletion Factors" summary tables); and potential volumetric limits are calculated and reported in the summary tables for 1) farm headgate deliveries, 2) consumptive use, 3) farm headgate depletions, and 4) stream depletions. These values could be used for operational limits for future administration of the subject water rights. With the "HB1248" dataset selected, only the "Max10yr" and "none" options are available. For other datasets the options available are:

o "Max10yr" option

The maximum cumulative value over any 10 year period within the study period is selected and displayed in the summary tables and used for simulation.

o "Avg10yr" option

The average cumulative value over any 10 year period within the study period is selected and displayed in the summary tables and used for simulation.

o "Max5yr" option

The maximum cumulative value over any 5 year period within the study period is selected and displayed in the summary tables and used for simulation.

o "Avg5yr" option

The average cumulative value over any 5 year period within the study period is selected and displayed in the summary tables and used for simulation.

o "Max20yr" option

The maximum cumulative value over any 20 year period within the study period is selected and displayed in the summary tables and used for simulation.

o "Avg20yr" option

The average cumulative value over any 20 year period within the study period is selected and displayed in the summary tables and used for simulation.

- "Lag On/Off" column

The "Lag On/Off" column indicates if a unit response function (URF) from the "_data" worksheet will be used to determine "lagged" return flows to the stream. URFs describe the relationship between groundwater return flow and lease-fallowing decisions that affect the volume of recharge to the groundwater table. For more information see the LFT Reference Manual. Currently, for Colorado Division 2 ditch-wide URFs developed for the HI model (using a regional 2-D groundwater model) are input into the "_data" spreadsheet that is created when the "Build Input Data Pages" button is used. However, it often is more appropriate for the user to enter a locally-specific URF for analysis.

- "ON"

    With the lag option set to "ON", a URF will be utilized to determine lagged groundwater return flows to the stream and historical stream depletions. Additional tables will be tabulated for estimates of stream depletion or the change in return flows as measured at the stream between historic conditions and the fallowing condition. The "HB1248" dataset option does not allow selection of this option and summary tables will end with the calculation of "on-farm" depletions.

- "OFF"

    The "OFF" option is selected if the user does not wish to calculate groundwater return flow to the stream and stream depletion due to fallowing. A URF is still required for the LFT to run in order to produce a table of delayed return flows remaining to the stream.

- "Effective Precip Options - PartialMonth" column

This column determines the amount of effective precipitation used to calculate the irrigation water requirement for the parcel. Entry is not required, and will default to "no-ISAM/HI".

- "no-ISAM/HI"

    A "no-ISAM/HI" selection will result in comparison of monthly PET to monthly effective precipitation as is done in ISAM and the HI model. This is the only available option when the "HB1248" or "HIM" datasets are selected.

- "yes-StateCU"

    A "yes-StateCU" is selected if the user wants the effective precipitation to be prorated to partial months when growing seasons start mid-month. If selected, growing season start/stop dates are required in the input page.

- "Effective Precip Options - Excess" column

The "Excess" column refers to excess effective precipitation (EEP), which is the amount of monthly effective precipitation that exceeds PET demand and is added to soil moisture. When "yes-ISAM/HI" is selected all EEP for the full year will be considered (as is done in ISAM and the HI model), when "no-winter" is selected EEP will not be considered for periods of no PET demand, and when "none" (as in StateCU) is selected no EEP will be considered. The "no-winter" option requires crop-specific PET in the input page. No selection is required and the option will default to "yes-ISAM/HI".

- "Extra SheetID" column

If an extra sheet ID is entered in the "Extra SheetID" column (not required), it will modify the worksheet name for the summary table produced for the scenario run to the sheetID specified. Users can change the Extra Sheet ID to run a new scenario while retaining the results from a previous scenario, as documented in the summary tables (the results tables will be overwritten). This is a convenient way to compare results in the summary tables based on slightly modified scenarios, but still using the same input data page. For example, the user can append an "a", "b", or "c" to the original sheet ID to create a table of results based on changes made to the simulation, but with a slightly different name to avoid overwriting the old results.

- **RUN LFT ANALYSIS** button

The "RUN LFT ANALYSIS" button runs the primary LFT parcel water balance and return flow analysis and creates results and summary tables. If the "MCR_CACHE_ROOT" environment variable is not set (as described previously) and the LFT is being run for the first time after starting Windows, the code can take up to a minute to run but subsequent runs should run more quickly.

The button will initialize code to save the entire spreadsheet, create a .csv file, and initialize the MATLAB executable. For the MATLAB code to be able to write into the spreadsheet, the spreadsheet must be closed. This will happen automatically, and the spreadsheet will reopen automatically after the code has run successfully.

After the spreadsheet reopens, summary pages will be shown with hyperlinks in the "LFTparcels" worksheet.

Figure 8. Screenshot of the "Links" section of the "LFTparcels" worksheet. Each of the cells contains a hyperlink which, when selected, brings the user to the corresponding input or results page.

5. Links

The "Input Data", "Result Data", and "Summary Tables" columns provide hyperlinks to more easily navigate to their respective tables within the Excel workbook. These will fill automatically once the data tables are populated and the calculations are performed. If these links do not update correctly, pressing the "F9" key will correct the link values. On the summary table page, there is also a link below "Table 1" that navigates back to the "LFTparcels" page.

Land Parcel "_data" Worksheet

The "_data" worksheet contains information about the lease-fallowed land parcel being analyzed. The top of the worksheet shows the ID of the parcel represented, with its corresponding irrigation ditch identified both by its "Ditch ID" and name. Rows 4 and 5 describe the type of data that is listed below it. When creating or modifying the data page, the LFT will often place a comment in Row 3 that provides more information on the source of supplied data or manipulations that were made to that data. Yearly data is listed sequentially starting in row 6, beginning at the year "BegYear" as specified by the user on the "LFTparcels" worksheet, and ending at year "EndYear".

The first several columns allow the user to input the number of acres within the parcel that are irrigated with flood, sprinkler, or drip irrigation. The number of ditch shares associated with the parcel ("Farm Shares") also can be entered. If available, data from the HI or CDSS models are used to fill in the number of ditch shares and ditch acres available to the lease-fallowed land parcel being evaluated. If available, values for the ditch loss, off-farm lateral loss, and on-farm lateral loss, as a fraction of total available water, also are entered by default.

Information regarding the characteristics of the methods of irrigation is presented, allowing the user to alter the characteristics to reflect actual irrigation practices. When the "HB1248" dataset is not selected, the application efficiency (AE) of each method of irrigation is set by default to values used in the HI or CDSS models (in Colorado Division 2 in HI model area flood efficiency = 0.65 or 0.70, sprinkler efficiency = 0.85, and spray losses = 0; in Colorado Division 3 flood efficiency = 0.50 or 0.60, sprinkler efficiency = 0.80, and spray losses = 0.03). The tailwater (TW) factor, expressed as a fraction of Farm Headgate Delivery (FHGD), is initially 0.1 (10%). When the HB1248 option is selected, all application efficiencies are set to 0.55 (55%) regardless of irrigation method and the spray loss is set to 0.

Tailwater, which represents the volume of surface water which leaves the downstream (tail) end of a parcel following an irrigation event, can be constrained to a certain fraction of the total surface and subsurface return flows from the parcel. The user can enter a value (0-1) in the column labeled "Force TW % of RF"; if the user desires the model to calculate tailwater without restraint, a negative number is entered.

Data for Available Water Content (AWC) and Rooting Depth is supplied by the LFT from the CDSS or HI models for a ditch when available or using a standard value when using the HB1248 option. When not using the HB1248 of HIM datasets, crop distributions are changed by the user, and the PET is updated using the LFT, rooting depths will be modified annually based on the annual crop distribution and individual crop rooting depths (as described later).

- Ditch Diversion

The diversions from the ditch identified as supplying the land parcel with water are shown for each month of each year of the user-specified study period. Values are reported as diversions at the ditch headgate in acre-feet. The LFT can supply ditch diversion data for the ditches contained within its supplied databases. The ditch diversions for CODiv1 and CODiv3 were taken from the respective CDSS models. The ditch diversions for CODiv2 are only available for H-I Model ditches and in most cases were derived from diversion records in Hydrobase that were aggregated by water classes. Attention should be paid to diversion data supplied by the LFT and the user may often need to refine diversion data appropriately.

- PET

The PET, reported in inches, is calculated for each month of each year and should characterize the overall PET for the areas and crop types associated with land being considered on the data page (ie one page could describe one individual parcel or a larger set of parcels within a farm unit or even an entire ditch). The LFT can initially enter ditchwide PET into the data page that is based on individual crop PET and ditchwide crop distributions, when available. Depending on the dataset selected, the PET may be based on the ASCE standardized method, the Modified Blaney-Criddle with TR-21 crop coefficients, or the Modified Blaney-Criddle with calibrated crop coefficients. The climate data used to calculate this supplied data is based on the

climate station designated by the user on the "LFTparcels" worksheet; this is typically the station closest to the irrigated area. The user may change the crop distribution and have the LFT update the overall PET based on the individual crop PET.

- Precipitation

Climate data are acquired from the NOAA or CoAgMet weather station selected by the user on the "LFTparcels" worksheet, and usually correspond to the station closest to the irrigated area. Precipitation values are reported in inches. For analysis, the LFT currently only uses the Bureau of Reclamation method to calculate effective precipitation.

- Crop Distribution

The crop distribution for each day in the study period describes the portion of the land parcel (or set of parcels described by the data page) covered by various crop types. When available, the LFT can supply ditchwide crop distributions from the CDSS or HI models. Supplied values are normalized so that all values sum to 1 and can be viewed as a fraction of the total available land area. The user may often want to update the crop distribution from the supplied ditchwide distribution given parcel specific information.

- URF

For each month of analysis, the URF represents the relative amount of the total return flow from the irrigated parcel that returns to the stream in a given month. URFs may be supplied by the LFT for Colorado Division 2 for the H-I Model area, but the user may need to modify this URF based on localized conditions. URFs are not provided in other Divisions.

- Crop Specific PET

The remaining tables on the "_data" worksheet display the PET for each of the crop types in the "Crop Distribution" table. Values are in inches. As mentioned, the method used to calculate crop specific PET is based on the dataset option selected by the user. The last block of data is an estimate of non-growing season demand that is calculated using the H-I Model methodology. Below each crop PET table and indicated by the "Mult:" title is a row of multiplicative factors that will be applied by the LFT when ditch-wide PET is calculated. For example, these factors can be used to apply monthly calibration or elevation correction factors to calculate overall PET. When the input data page is initially created, these factors are set to "1.0" for all crops although the factors for the non-growing season demand is set to zero. Just below the factors, a crop specific rooting depth is also supplied. This crop rooting factor can be used by the LFT to recalculate overall rooting depth that may change annually based on a changing crop distributions. Both the multiplicative factors and crop specific rooting depths are applied when the "Update PET for Crop Dist" button is selected in the "LFTparcels" page.

Land Parcel "_S" Worksheet

The "_S" worksheet provides the user with a series of summary tables for each land parcel being evaluated. The general format and content of these tables was defined in the process used to develop the HB13-1248 Criteria and Guidelines. Data are summarized for the summary period designated by the user in the "Analysis and Summary Table Options" section of the "LFTparcels" worksheet.

- Table Summary contains a summary of the information displayed in the remaining tables on the "_S" worksheet. The top of the table shows the name of the land parcel for which information is being displayed and the summary period over which analysis is being performed. Clicking the blue hyperlinks throughout the table allows the user quick access to the table from which summary information was extracted.

  - The first section of Table Summary displays the average and maximum values for the number of parcel water shares and parcel acres being analyzed for the current land parcel, the irrigation application efficiency amongst the three irrigation methods (e.g. flood, sprinkler, drip), and the crop distribution of the land parcel between the crop types presented. Data summarized in this portion of Table summary are derived from Table 4, where more detailed information on crop acreages and crop distributions can be found.

- The "River Headgate Diversions for All Sources Considered in Pilot Project Plan" section gives an average, in acre-feet, of the volume of diversions from the irrigation ditch designated by the user. Values are given as an overall average for each month over all years of the summary period. Data are summarized in Table 1, where detailed diversion values for each month of each year of the summary period can be found.

- The "Farm Headgate Delivery" section corresponds to Table 3, which summarizes the volume of water delivered to the headgate(s) of the parcel(s) on the land parcel being evaluated. Values are in acre-feet, and take into account the ditch loss and off-farm lateral loss specified by the user on the "LFTparcels" worksheet.

- "Farm Crop Potential Evapotranspiration" provides a summary of information shown in Table 5, which contains monthly summations of PET for crops on the land parcel in acre-feet.

- The "Farm Effective Precipitation" section displays the average effective precipitation for each month of every year of the summary period. The monthly values for each year are shown in Table 7, and are calculated as the percentage of rainfall which infiltrates to become available to crops after losses from runoff and evaporation.

- "Farm Irrigation Water Requirement" describes the quantity of water, exclusive of precipitation, that is required for crop production. Monthly information is shown in Table 8, and is expressed in acre-feet.

- The "Farm Crop Irrigation Requirement Met by Irrigation Water Applied or in Soil Moisture" section relates to the "Farm Irrigation Water Requirement". It describes how much of the total volume of water required by the crop is supplied by either applied irrigation water or stored soil moisture. Monthly values for the summary period are derived from the Water Budget Balance, and are shown in Table 10. It should be noted that values do not include excess effective precipitation used by the crop.

- "Total Return Flows at Farm" describes the total volume of surface and subsurface water, in acre-feet, that leaves the parcel following the application of irrigation water. Monthly values for each year of the summary period are shown in Table 11, and do not include excess effective precipitation that deep percolates.

  - "Tailwater/Surface Runoff Return Flows at Farm" represents the portion of farm return flows that leave the parcel as surface runoff, and does not include water that has infiltrated into the soil. Expressed as a fraction of total applied water, values can change depending on the irrigation application method chosen. Table 12 shows monthly values for each year of the summary period, expressed in acre-feet.

  - "Deep Percolation/Ground Water Return Flows at Farm (unlagged)" represents the portion of total return flows in the form of deep percolation. Table 13 contains monthly summations, in acre-feet, for each year of the summary period.

- The "Historical Depletions at Farm" section represents the amount of water consumed by crops on the parcel. It is calculated as difference between the total volume of parcel headgate delivery and the total return flows. Table 14 contains the monthly summations for each year of the summary period, which also are summarized in Table 1.

- "Historical Delayed Return Flow Remaining to the Stream after Diversions have Ceased" describes the volume of water that leaves the parcel as either surface runoff or groundwater return flows after ditch diversions have been stopped. Summarized in Table 20, the amount of return flow remaining after the last diversion is shown in bold, and also is tabulated in the last column for easier reference.

- The "Delayed Return Flows Remaining to Stream as Percent of Cumulative Farm Headgate Deliveries" are shown in Table 21. This section summarizes the cumulative remaining return flows from each calendar year's diversions as a portion of the cumulative parcel headgate delivery. Similar to the data in Table 20, bold values indicate the amount after the last diversion, which also are tabulated in the last column.

- Tables 22, 23, and 28 contain additional information made available if further analysis is desired. Table 22 displays the volume of transferable depletions as a function of the calculated on-farm depletion factors. Table 23 shows a comparison of historical on-farm depletions to the calculated transferrable depletions in Table 22. Table 28 contains input data used for analysis, including loss coefficients, application efficiencies, and variables pertaining to available soil moisture.

Land Parcel "_R" Worksheet

The "_R" worksheet provides the user with results tables for most of the variables calculated by the LFT during analysis. In contrast to the "_S" worksheet, which contains summary information for a designated summary period, tables on the "_R" worksheet contain monthly information for each year of the study period designated in the "Input Data Options" section of the "LFTparcels" worksheet.

The column on the left side of the worksheet under "Links to Results Tables" contains links to the various results tables. Further description of the variables that each table contains can be found in the glossary.

Glossary

AF: acre-foot; a unit of volume used to quantify large-scale water resources. It is defined as the volume of a depth of water of one foot on one acre of surface area.

Canal Seepage: the portion of water lost during conveyance through an irrigation ditch between the ditch headgate and farm laterals via infiltration to the groundwater.

Consumptive Irrigation Requirement (CIR): the volume of water, excluding precipitation, that is required for crop production.

Deep Percolation: the volume of water that moves downward out of the crop root zone to recharge the groundwater.

Ditch Diversion: the volume of water diverted from a river into an irrigation ditch as measured at the ditch headgate typically located near the river.

Effective Precipitation: the percentage of rainfall which becomes available to crops when infiltrated and stored in the soil, considering runoff and surface evaporation.

Excess Effective Precipitation: the portion of effective precipitation that exceeds the amount that can be transpired by crops.

Farm: an area of land, typically consisting of multiple parcels, used for growing crops and rearing animals

Farm Headgate (FHG): a flow control at the upstream end of a parcel where water is delivered from diversion ditches.

FHGD available to meet CIR: the volume of water delivered to the farm headgate that can contribute to the crop consumptive irrigation requirement.

HI Model: Hydrologic-Institutional Model used to calculate annual depletions and accretions to the Arkansas River by simulating hydrologic and institutional systems located between Pueblo, Colorado and the Colorado-Kansas Stateline.

Irrigation Demand: the quantity of irrigation water necessary to apply to meet crop water demand. It accounts for PET, surface runoff, and deep percolation, as well as water lost during water delivery to the parcel.

Off-Farm/On-Farm Lateral Loss: the volume of water lost from farm lateral ditches or pipes which deliver water from canal turnouts or control valves to the point of application on the parcel.

Parcel: an area of land used for growing crops, also known as a field

Percolation Returns: the portion of deep percolation that returns to the stream system.

Pond Seepage: the volume of water lost from irrigation storage ponds due to infiltration to the groundwater.

Potential Evapotranspiration (PET): the amount of evaporation and plant transpiration that would occur if sufficient water supply were available. PET depends upon temperature, solar radiation, relative humidity, and wind speed, among other variables.

Residual: the magnitude of computing errors present during the external farm-level water balance performed by ISAM.

Return Flows Unlagged: the total volume of surface and subsurface water that leaves a parcel of land following an irrigation event.

Secondary Evapotranspiration (SEV) Losses: the portion of surface water return flow consumed by plants located in drainage canals. If this term is zero, Tailwater is equal to Tailwater Returns.

Soil Moisture: the volumetric quantity of water stored within the crop root zone in the soil.

Spray Loss: the volume of water lost during sprinkler irrigation due to wind drift or evaporation.

Supply at FHG: the volume of water delivered to the farm headgate from diversion ditches after conveyance losses.

Supply at Parcel: the volume of water available for crop water use. It is the combination of FHG supply and effective precipitation, minus on-farm lateral losses, tailwater, spray loss, and initial deep percolation (the volume of deep percolation prior to irrigation).

Tailwater: the volume of applied irrigation water that runs off via surface flow at the downstream end of the parcel.

Tailwater Returns: the portion of tailwater that is returned to the stream system after removal of potential SEV losses due to phreatophyte consumption.

Usable Supply: the water supply at the parcel plus the change in soil moisture that is consumed by the crop during the fallowing scenario.

Appendix: Diagram of Selected Dataset Options

Dataset   **Climate Station**   **Soil Moisture Wrap**

| HIM |

| HIM approved ditch-wide climate data |

| CoAgMet Climate Stations |

| None |

| Study Period |

| Full Period |

| Enter (User Input) |

| HB1248 |

| Closest to irrigated area (chosen by the tool) |

| Study Period |

| MBCTR21 |

| Closest to irrigated area (chosen by the tool) |

| NOAA Climate Station |

| None |

| Study Period |

| Full Period |

| Enter (User Input) |