

Cumberland County Regional Water Supply Plan

October 22, 2015



US Army Corps
of Engineers.
Nashville District



PRESENTATION OVERVIEW



- » Introductions
- » Project history
- » Systems model
- » Current scope
- » Recommendations



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PROJECT HISTORY



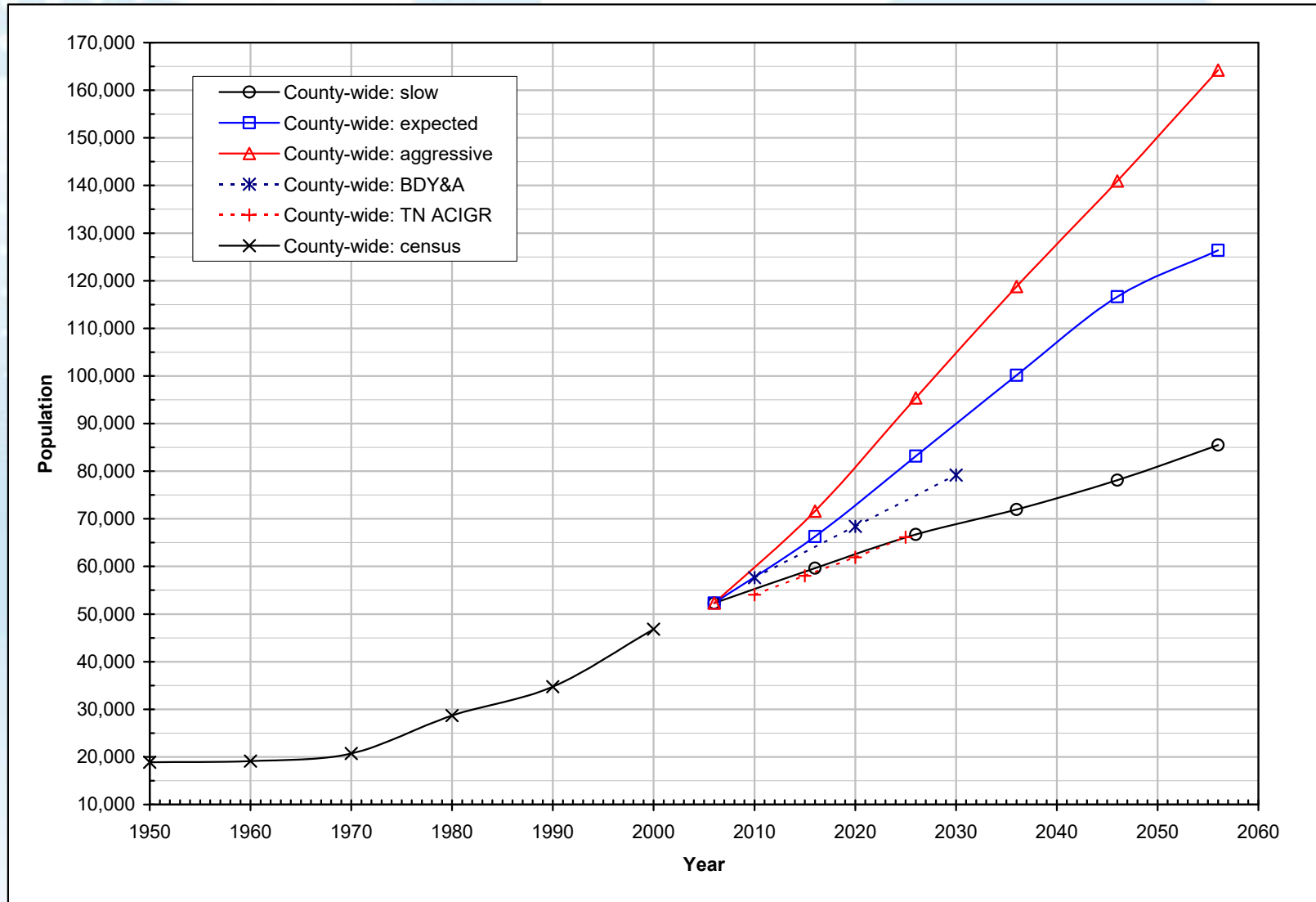
- » Population projections
- » Regional water demand projections
- » System-wide data collection and model development



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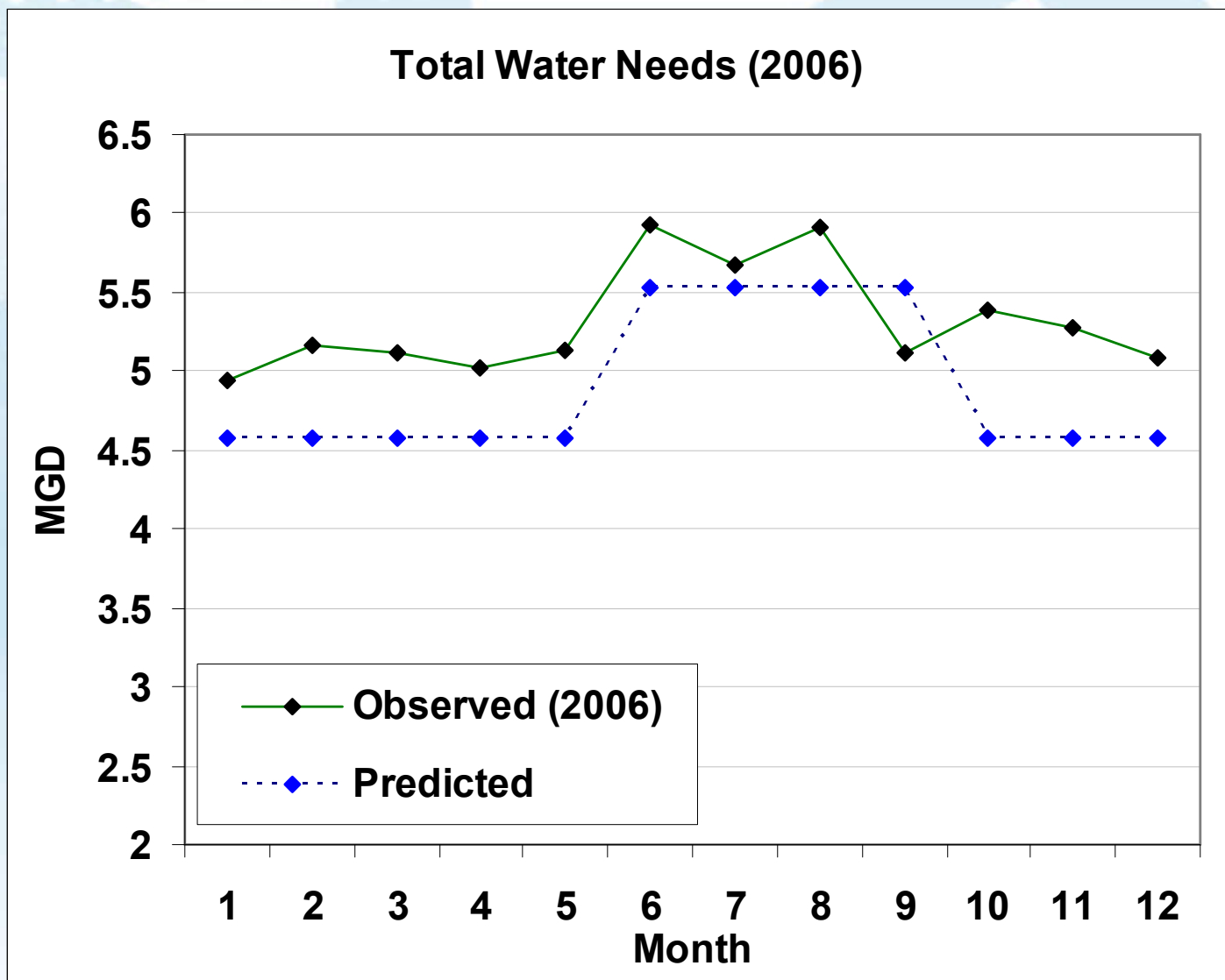
PROJECT HISTORY

POPULATION PROJECTIONS



PROJECT HISTORY

PREDICTED AND OBSERVED CUMBERLAND COUNTY DEMAND



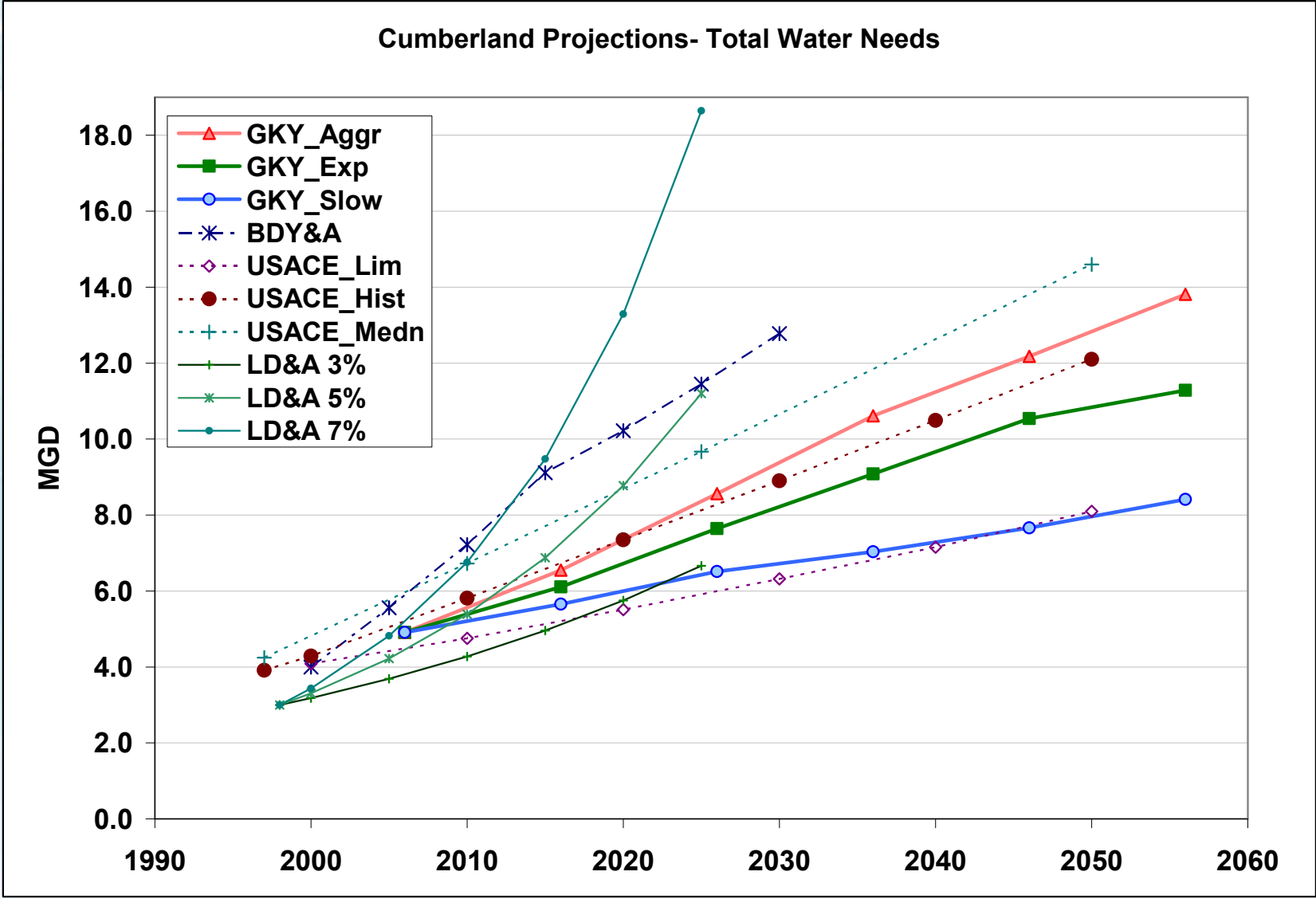
*Above average losses in 2006



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PROJECT HISTORY

DEMAND PROJECTIONS



SYSTEMS MODEL DEMAND

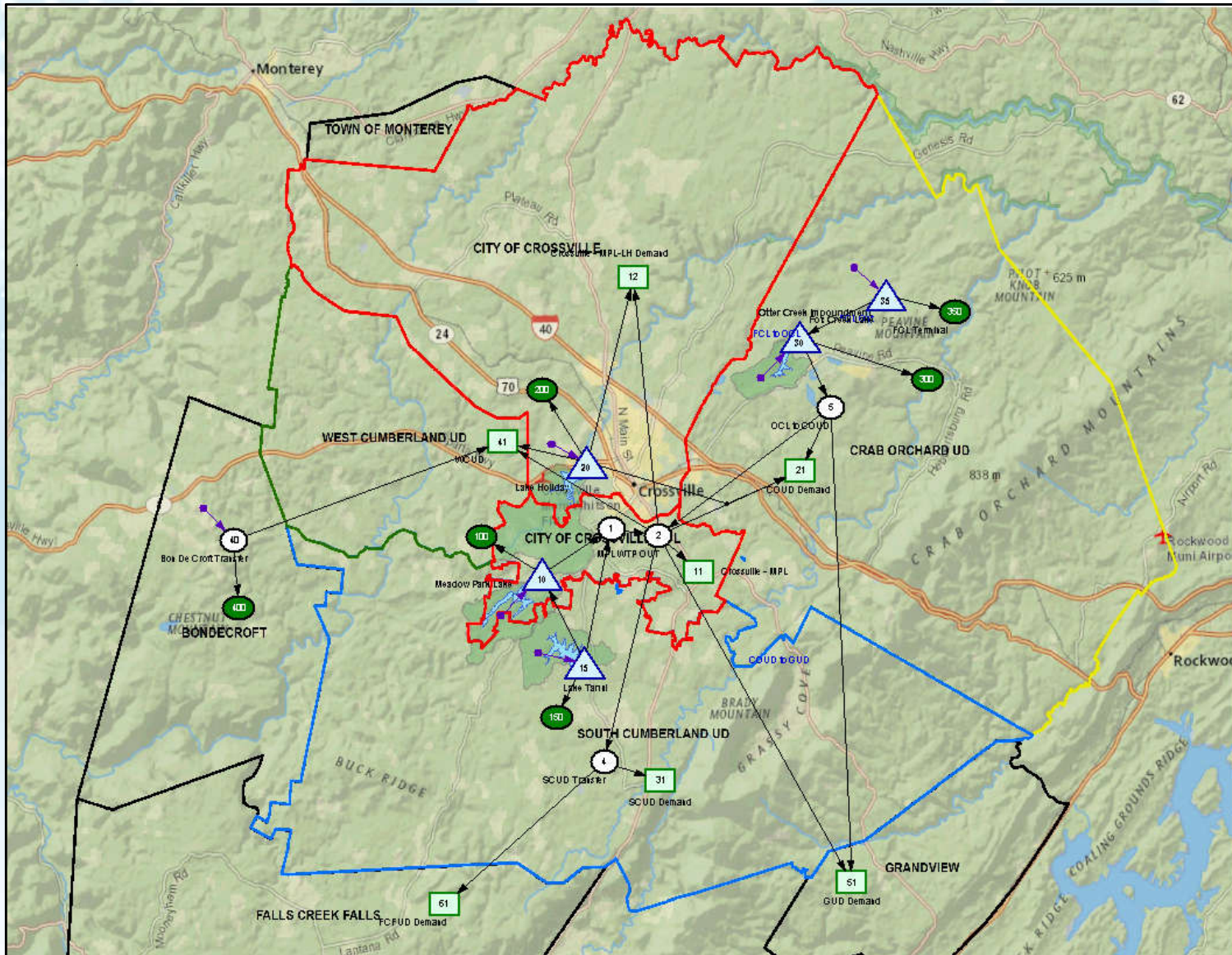


- » Used demand forecast from GKY analysis
- » Disaggregated demand using 2006 parcel data
- » GKY “expected” growth scenario
- » Summer (June through Sept - 1.12) and winter (0.94) demand multipliers derived from 5 years of Crossville water-use records
- » Demand nodes: Crab Orchard UD, Crossville (MPL/Holiday), Crossville (MPL/Holiday Optional, Crossville (MPL Only), South Cumberland UD, West Cumberland UD, Falls Creek Falls UD, Grandview UD

Service Area	2006	2016	2026	2036	2046	2056
Crab Orchard	1.17	1.54	2.17	3.01	3.89	4.14
Crossville (Total)	2.95	3.47	3.87	4.01	4.19	4.37
Crossville (MPL/Holiday)	2.27	2.73	3.08	3.21	3.38	3.54
Crossville (MPL/Holiday Optional)	0.43	0.45	0.47	0.48	0.49	0.5
Crossville (MPL Only)	0.25	0.29	0.32	0.32	0.32	0.33
South Cumberland	0.56	0.83	1.32	1.74	2.12	2.38
West Cumberland	0.24	0.26	0.29	0.31	0.34	0.4
Falls Creek Falls	0.00	0.03	0.07	0.10	0.13	0.17
Grandview	0.09	0.11	0.14	0.17	0.20	0.25
Total	5.01	6.25	7.85	9.35	10.87	11.71



SYSTEMS MODEL MODEL SCHEMATIC



SYSTEMS MODEL SETUP OASIS



DASIS with OCL --- Run directory: D:\ageorgeGKY_TN_OASIS\Runs\Simulation\Cumb_Existing_2036_wdrought_WTP\lfted [Simulation Mode]

File Edit Run Output Help

Schematic Setup Time Node Arc OCL Misc

Zoom 100 %

Nodes: [Shapes] Arcs: [Arrows]

Reservoir Storage-Area-Elevation at Node 30, 'Otter Creek Impoundment'

Elevation	Storage	Area
1705.000	63.996	6.400
1715.000	215.080	15.108
1725.000	487.112	27.203
1735.000	904.006	41.689
1745.000	1482.108	57.810
1755.000	2238.618	75.651
1765.000	3193.230	95.461
1772.500	3757.780	112.910
1775.000	4363.539	121.152
1776.000	4998.090	126.910
1780.000	5655.676	131.517

Units: Elevation: FT, Storage: ACFT, Area: Acres

X-Variable: [] Y-Variable: []

Source of Inflow: Series []

Data Source of Evaporation: [None]

Edit Reservoir Storage / Area / Elevation Data

Weight	Pri	Description
1	1	D - Zone
50	1	C - Zone
110	1	B - Zone
600	1	A - Zone

The A Zone is the lowest storage zone. Each zone must have higher (more positive) weight than the zone above it.

```

/* TOTAL SYSTEM */
/* Compute usable storage variables */
Set: MFL_Usable_Stor [ volum : max ( 0, storage010 - lower_rule010 ) ]
Set: MFL_Total_Usable_Stor [ volum : upper_rule010 - lower_rule010 ]
Set: LH_Usable_Stor [ volum : max ( 0, storage015 - lower_rule015 ) ]
Set: LH_Total_Usable_Stor [ volum : upper_rule016 - lower_rule015 ]
Set: LH_Usable_Stor [ volum : max ( 0, storage020 - lower_rule020 ) ]
Set: LH_Total_Usable_Stor [ volum : upper_rule020 - lower_rule020 ]
Set: OC_Usable_Stor [ volum : max ( 0, storage030 - lower_rule030 ) ]
Set: OC_Total_Usable_Stor [ volum : upper_rule030 - lower_rule030 ]
Set: TS_Usable_Stor [ volum : MFL_Usable_Stor + LH_Usable_Stor + OC_Usable_Stor ]
Set: TS_Total_Stor [ volum : MFL_Total_Usable_Stor + LH_Total_Usable_Stor + OC_Total_Usable_Stor ]
Set: TS_PctFull [ volum : TS_Usable_Stor / TS_Total_Stor ]
Set: TS_Demand [ volum : ddemand011 + ddemand012 + ddemand021 + ddemand031 + ddemand041 + ddemand051 ]
Set: TS_Dem_Demand [ volum : ( ( ( MFL_Demand ) + ( LH_Demand ) + ( OC_Demand ) + ( MFL_Demand ) + ( OC_Demand ) + ( OC_Demand ) ) ) ]
Set: TS_Delivery [ volum : delivery011 + delivery012 + delivery021 + delivery031 + delivery041 + delivery051 + delivery061 ]
Set: TS_Shortage [ volum : shortage011 + shortage012 + shortage021 + shortage031 + shortage041 + shortage051 + shortage061 ]
Set: TS_DaysStor [ volum : TS_Usable_Stor / TS_Demand ]
Set: Elevation_MFL [ volum : elevation010 ]
Set: Elevation_LH [ volum : elevation020 ]
Set: Elevation_LI [ volum : elevation015 ]
Set: Elevation_OC [ volum : elevation030 ]
/* Turn on triggers */
Set: TS_Stage1_Drought_On
    
```

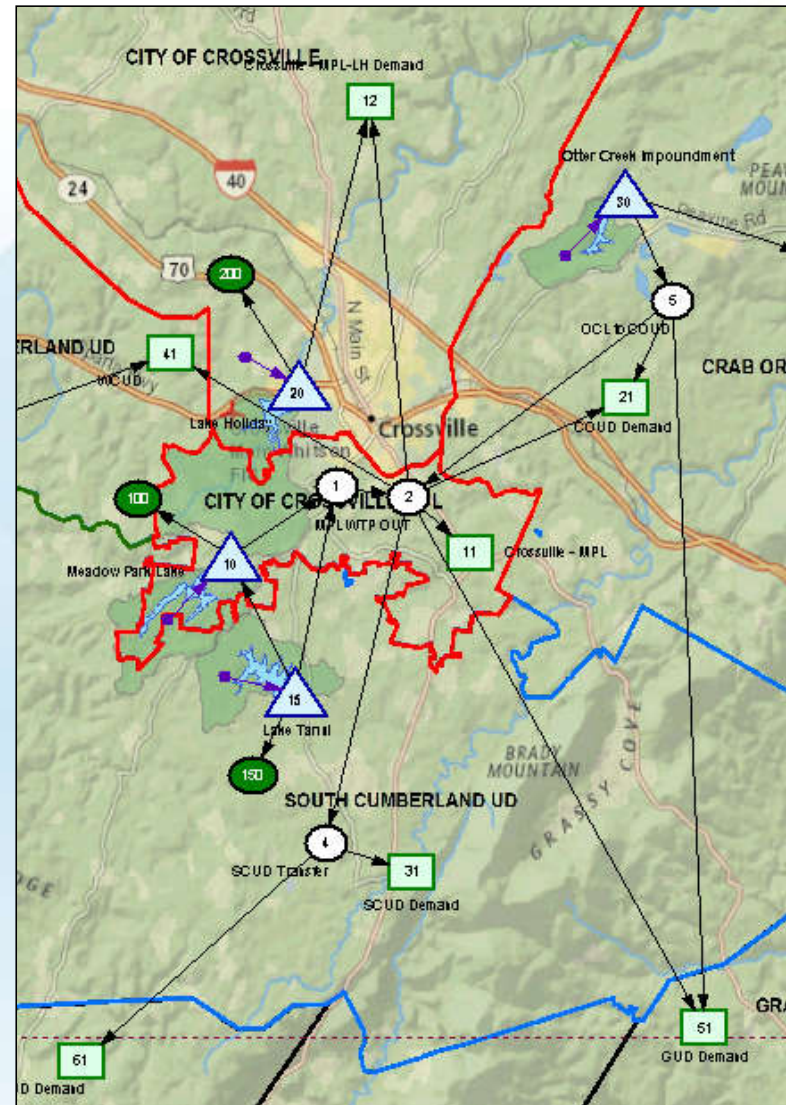
Output CURRENT Node 030: Otter Creek Impoundment

Start [Icons] 3:19 PM 9/5/2012



SYSTEMS MODEL CITY OF CROSSVILLE

- » Split into two demand nodes
- » Sells water to South Cumberland UD, Grandview UD, Falls Creek Falls UD
- » Emergency connections with Crab Orchard UD, Town of Monterey, and West Cumberland UD
- » Three core water supply sources: Meadow Park Lake, Lake Holiday, and Lake Tansi
- » The model also includes two Crab Orchard UD sources: Otter Creek Lake and Fox Creek Lake (an optional new water supply northeast of Otter Creek)



CURRENT SCOPE



- » Determine areas of need for additional water supply
 - » 1A: Reduce usable storage 10% and 20% (safety factor)
 - » 2A: 1A and relax WTP capacity constraints
 - » 3A: 2A and remove institutional constraints
 - » 4A: 3A and increase Lake Holiday service area (existing)
 - » 5A: 4A and relax physical interconnection constraints
 - » 6A: 5A and increase Meadow Park Lake capacity
 - » 7A: 6A and add Fox Creek Lake to Crab Orchard UD
 - » Test above scenarios for other sequencing
- » Identify and recommend potential alternatives



RECOMMENDED UPGRADES



<u>Scenario/Upgrade Description</u>	<u>When Due</u>
» Relax WTP capacities	(2016-56)
» Lake Holiday WTP = 2.0 MGD	<i>constraint removed</i>
» Meadow Park Lake WTP = 3.5 MGD	<i>constraint removed</i>
» Crab Orchard WTP = 4.0 MGD	<i>constraint removed</i>
» Relax institutional constraints	(2026-36)
» <i>Open 5 existing but unused connections:</i> MPL to W Cumberland, Crab Orchard to Grandview, Crab Orchard to Crossville, MPL to Crab Orchard, and MPL to S Cumberland	
» Expand Lake Holiday service area	(2026-36)
» <i>Open 2 existing but unused connections:</i> LH to Crab Orchard, and LH to W Cumberland	
» <i>Shift the model demand</i> so that both MPL and LH can satisfy the “Crossville-Holiday Optional” demand.	



RECOMMENDED UPGRADES



<u>Scenario/Upgrade Description</u>	<u>When Due</u>
» Upgrade physical interconnections	(2036-56)
» Connection capacity upgrades MPL and LH to Crab Orchard, Crab Orchard to Crossville, Crab Orchard to Grandview, and MPL to S Cumberland	constraints removed
» Raise Meadow Park Lake dam	(2046-56)
» Increase the usable storage in MPL:	
» Current max pool elevation:	1818.20 ft
» Scenario 6A1 max pool elevation:	1836.70 ft



RECOMMENDED UPGRADE TIMELINE



Upgrade Description (Scenario)	<=	2016	--	2026	--	2036	--	2046	--	2056	=>
Expand WTP Capacities (2A)											
Relax Institutional Constraints (3A)											
Expand Lake Holiday Service Area (4A)											
Upgrade Physical Interconnections (5A1)											
Raise Meadow Park Lake Dam (6A1)											

= 10% Safety Factor
 = 20% Safety Factor

WTP Capacity¹ Timeline

Peak WTP Capacity (MGD)	Expand WTP Capacities (2A, 2016-26)	Relax Institutional Constraints (3A, 2026-36)	Expand Lake Holiday Service Area (4A, 2026-36)	Upgrade Physical Interconnections (5A1, 2036-46)	Raise Meadow Park Lake Dam (6A1, 2046-56)
MPL WTP	2.59	4.95	4.41	10.54	12.44
Lake Holiday WTP	3.44	3.58	4.12	4.50	4.50
Crab Orchard WTP	2.42	5.17	4.82	4.62	4.62

¹ Actual design capacity would be higher than simulation maximums presented herein





RECOMMENDED UPGRADE NOTE



- » A note about raising Meadow Park Lake:
 - » Scenario 6A1 meets all of the benchmark demands in 2056
 - » Scenario 6A1 raised MPL's normal pool 18.5 feet to 1836.7 feet
 - » But not all of MPL's usable storage was used up
 - » MPL only needs to be raised 7.8 feet to 1826 feet or 12.8 feet to 1831 feet with the 10% and 20% safety factors, respectively

Upgrade Description (Scenario)	<=	2016	--	2026	--	2036	--	2046	--	2056	=>
Expand WTP Capacities (2A)											
Relax Institutional Constraints (3A)											
Expand Lake Holiday Service Area (4A)											
Upgrade Physical Interconnections (5A1)											
Raise Meadow Park Lake Dam (6A1)											

 = 10% Safety Factor
 = 20% Safety Factor



UPGRADE TIMELINE: CONNECTIONS





Arc (Pipe) Name	U/S	D/S	Existing Physical Constraint (MGD)	Expand WTP Capacities (2A: 16-26)	Relax Institutional Constraints (3A: 26-36)	Expand Lake Holiday Service Area (4A: 26-36)	Upgrade Physical Interconnections (5A1: 36-46)	Raise Meadow Park Lake Dam (6A1: 46-56)
MPL WTP	1	2	3.50	2.59	4.95	4.41	10.54	12.44
C to SCUD	2	4	2.17	1.55	2.06	2.06	2.84	2.84
MPL WTP to Cross MPL	2	11	(3.50)	0.88	0.89	0.36	0.37	0.37
MPL WTP to Cross LH/MPL	2	12	(3.50)	0.00	0.00	0.00	3.74	4.38
C to CO	2	21	1.82	0.00	1.82	1.82	4.62	4.62
C to WC	2	41	0.50	0.00	0.00	0.00	0.00	0.00
Crossville to Grandview	2	51	0.72	0.16	0.19	0.19	0.28	0.28
Crossville to SCUD	4	31	(2.17)	1.47	1.94	1.94	2.66	2.66
Crossville to FCFUD	4	61	0.33	0.08	0.11	0.11	0.19	0.19
Crab Orch to Crossville	5	2	1.82	0.00	0.00	1.46	0.00	0.00
CO WTP to COUD	5	21	(4.00)	2.42	3.36	3.36	4.62	4.62
COUD to GUD	5	51	0.22	0.22	0.00	0.00	0.00	0.00
MPL to MPL WTP	10	1	(3.50)	2.59	4.95	4.41	10.55	12.44
Lake Tansi to MPL WTP	15	1	5.00	5.00	4.47	4.01	5.00	5.00
Lake Tansi to MPL	15	10	5.00	5.00	2.81	2.81	2.39	2.05
Lake Holiday to WTP	20	12	2.00	3.44	3.58	4.12	4.50	4.50
Holiday to COUD via Cross	20	21	1.82	0.00	0.00	1.82	4.62	4.62
Holiday to WCUD	20	41	0.5	0.00	0.00	0.00	0.00	0.00
OC to CO WTP	30	5	4.00	2.42	5.17	4.82	4.62	4.62
Bon De Croft to WCUD	40	41	0.75	0.32	0.35	0.35	0.38	0.45



QUESTIONS?

Upgrade Description (Scenario)	<=	2016	--	2026	--	2036	--	2046	--	2056	=>
Expand WTP Capacities (2A)											
Relax Institutional Constraints (3A)											
Expand Lake Holiday Service Area (4A)											
Upgrade Physical Interconnections (5A1)											
Raise Meadow Park Lake Dam (6A1)											

 = 10% Safety Factor
 = 20% Safety Factor



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MODELING RESULTS (8 Scenarios)



- » Each scenario/alternative adds to the assumptions in the last one, testing existing infrastructure alternatives.
- » Scenarios 1A_10% and 1A_20% referred to as the “x2” safety factors for the remaining scenarios.

Scenario	Description	Last Year of Firm Yield	Year: UD(s) That Experience Shortage
Existing	Base model with no upgrades	2016,2026,2036,2046,2056	2026: S. Cumb., Falls Crk Falls, Grandview
1A_10%	Reduce usable storage in MPL, LH, OCL by 10%	2016,2026,2036,2046,2056	2026: Crab Orch., S. Cumb., Falls Crk. Falls, Grandview
1A_20%	Reduce usable storage in MPL, LH, OCL by 20%	2016,2026,2036,2046,2056	2026: Crab Orch., S. Cumb., Falls Crk. Falls, Grandview
2A_10%	1A_10% & relax WTP constraints (TDEC req.)	2016,2026,2036,2046,2056	2026: Crab Orch.
2A_20%	1A_20% & relax WTP constraints (TDEC req.)	2016,2026,2036,2046,2056	2026: Crab Orch.
3A_10%	2A_10% & remove institutional constraints	2016,2026,2036,2046,2056	2036: Crab Orch.
3A_20%	2A_20% & remove institutional constraints	2016,2026,2036,2046,2056	2036: Crab Orch.
4A_10%	3A_10% & increase LH service area (existing connections)	2016,2026,2036,2046,2056	2036: Crab Orch.
4A_20%	3A_20% & increase LH service area (existing connections)	2016,2026,2036,2046,2056	2036: Crab Orch.



MODELING RESULTS (4 Sequences, 18)



- » Four sequences test new infrastructure/upgrades in different order.
- » Each scenario adds to the assumptions of the last one and the first 8.

Scenario	Description	Last Year of Firm Yield	Year: UD(s) That Experience Shortage
5A1_10%	4A_10% & relax physical interconnection constraints	2016,2026,2036,2046,2056	2056: All UD's
5A1_20%	4A_20% & relax physical interconnection constraints	2016,2026,2036,2046,2056	2046: All UD's except Crossville (MPL only), Crab Orch.
6A1_10%	5A1_10% & increase MPL usable storage by 18.5 feet	2016,2026,2036,2046,2056	2056: None
6A1_20%	5A1_20% & increase MPL usable storage by 18.5 feet	2016,2026,2036,2046,2056	2056: None
7A1_10%	6A1_10% & add FCL reservoir to COUD	2016,2026,2036,2046,2056	2056: None
7A1_20%	6A1_20% & add FCL reservoir to COUD	2016,2026,2036,2046,2056	2056: None
6A2_10%	5A1_10% & increase MPL usable storage by 20 feet	2016,2026,2036,2046,2056	2056: None
6A2_20%	5A1_20% & increase MPL usable storage by 20 feet	2016,2026,2036,2046,2056	2056: None
7A2_10%	6A2_10% & add FCL reservoir to COUD	2016,2026,2036,2046,2056	2056: None
7A2_20%	6A2_20% & add FCL reservoir to COUD	2016,2026,2036,2046,2056	2056: None
5A3_10%	4A_10% & add FCL reservoir to COUD	2016,2026,2036,2046,2056	2046: Crab Orch., S. Cumb., Fall Crk. Falls
5A3_20%	4A_20% & add FCL reservoir to COUD	2016,2026,2036,2046,2056	2046: Crab Orch., S. Cumb., Fall Crk. Falls
6A3_10%	5A3_10% & relax physical interconnection constraints	2016,2026,2036,2046,2056	2056: All UD's except Crossville (MPL only), Crab Orch.
6A3_20%	5A2_20% & relax physical interconnection constraints	2016,2026,2036,2046,2056	2056: All UD's except Crossville (MPL only)
7A3_10%	6A3_10% & increase MPL usable storage by 20 feet	2016,2026,2036,2046,2056	2056: None
7A3_20%	6A3_20% & increase MPL usable storage by 20 feet	2016,2026,2036,2046,2056	2056: None
5A4_10%	4A_10% & increase MPL usable storage by 18.5 feet	2016,2026,2036,2046,2056	2036: Crab Orch.
5A4_20%	4A_20% & increase MPL usable storage by 18.5 feet	2016,2026,2036,2046,2056	2036: Crab Orch.

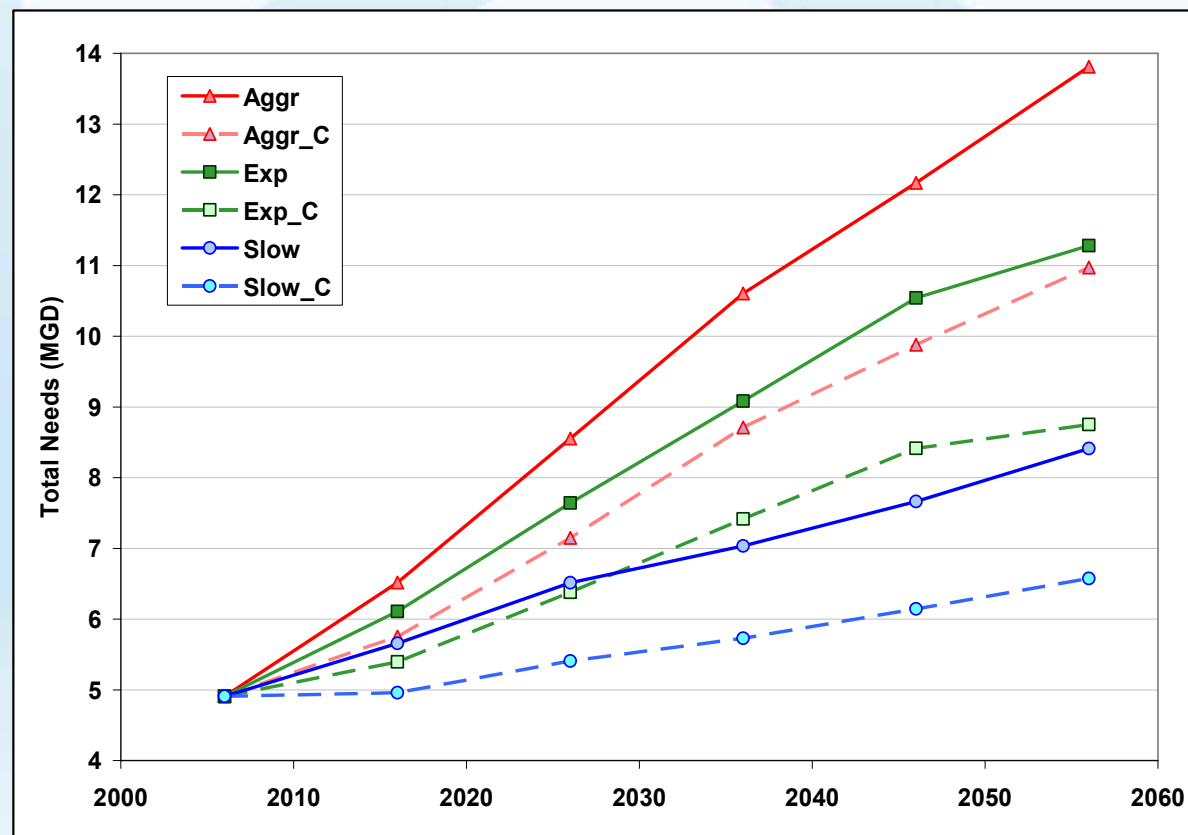


PROJECT HISTORY

CONSERVATION ANALYSIS



- » Non-leakage UAW reduction
- » Leakage reduction
- » Education programs
- » Codes and ordinances



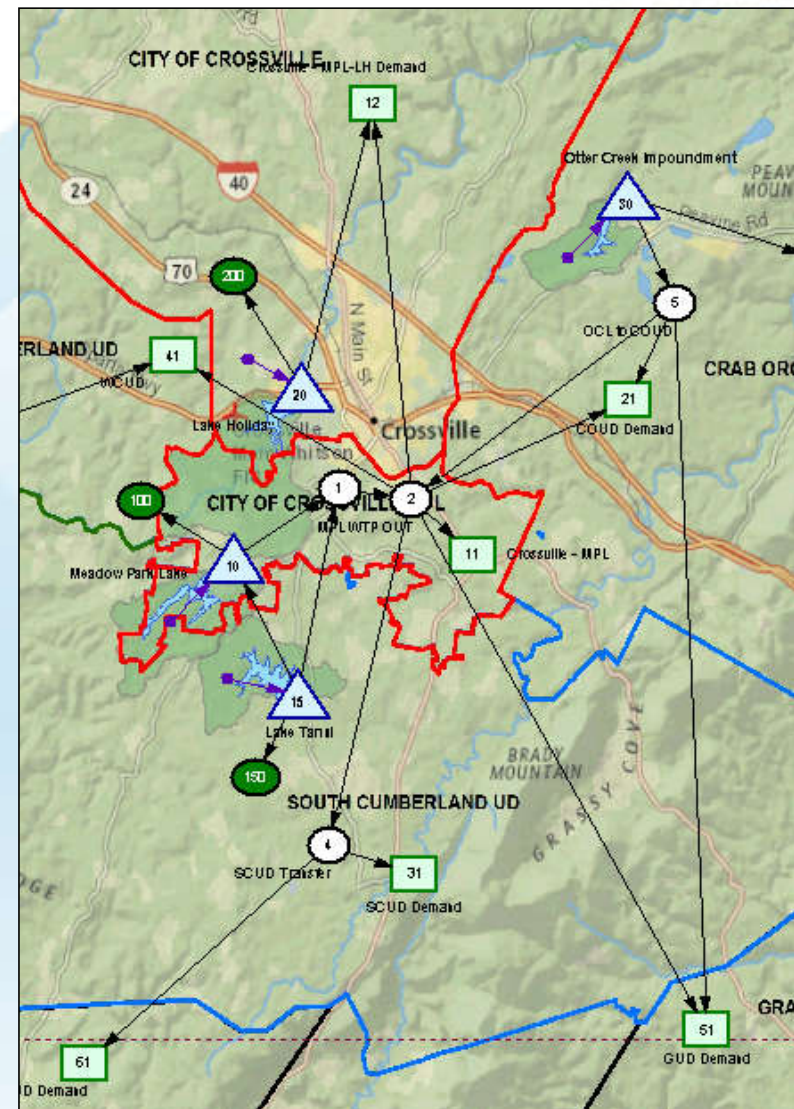
SYSTEMS MODEL CITY OF CROSSVILLE

Water Treatment (WTP)

- » Lake Holiday WTP Capacity = 2.0 MGD (4.0 MGD with increased staff)
- » Meadow Park Lake WTP Capacity = 3.5 MGD

Interconnections

- » To Crab Orchard UD = 1.8144 MGD (Emergencies Only)
- » To Falls Creek Falls UD = 0.3 MGD (Physical/Institutional)
- » To Grandview UD = 0.72 MGD (Physical)
- » To S. Cumberland UD = 2.174 MGD (Physical)
- » To West Cumberland UD = 0.504 MGD (Emergencies Only)
- » From Town of Monterey = 0.2 MGD (Institutional) - not modeled



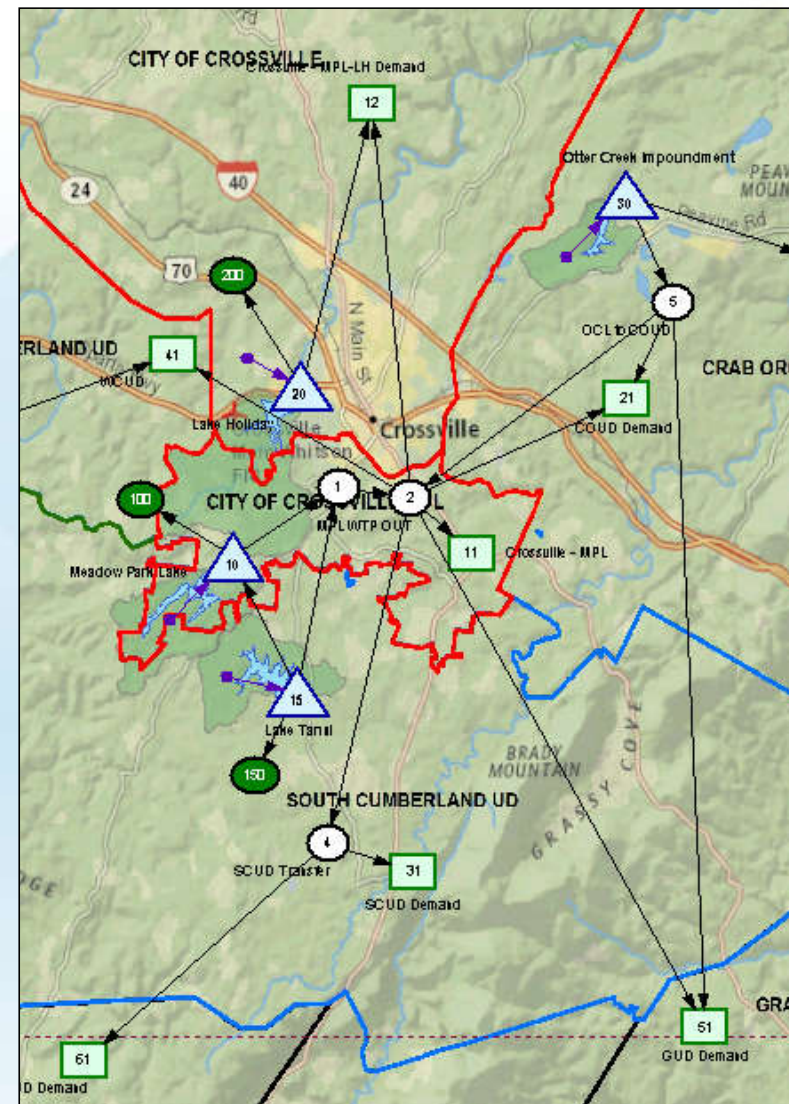
SYSTEMS MODEL CITY OF CROSSVILLE

Water Supply

- » Lake Holiday
 - » Normal Pool @ 1761.25
 - » Low Intake @ 1742
- » Meadow Park Lake
 - » Normal Pool @ 1812.20
 - » Low Intake @ 1803.6
- » Lake Tansi
 - » Normal Pool @ 1861.71
 - » Low Intake @ 1858.25

Lake Tansi Connection

- » Primary transfer to MPL WTP
- » Able to transfer to both WTP and MPL with 14 MGD pump capacity
- » Does not operate April 15 – October 15
- » Allowed to take overflow and draw down 4” from normal pool October 15 – April 15



SYSTEMS MODEL CRAB ORCHARD UD

Water Treatment (WTP)

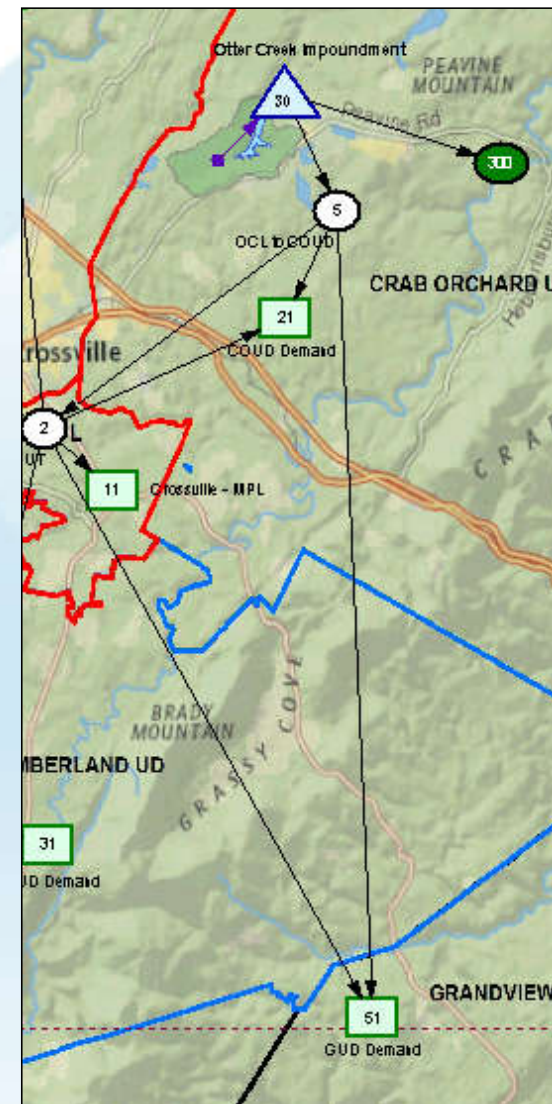
- » Crab Orchard WTP Capacity = 4.0 MGD

Interconnections

- » To Crossville = TBD (Emergencies Only)
- » To Grandview UD = 0.216 MGD (Emergencies Only)

Water Supply

- » Otter Creek Lake
 - » Normal Pool @ 1775
 - » Low Intake @ 1755



SYSTEMS MODEL SOUTH CUMBERLAND UD

Water Treatment (WTP)

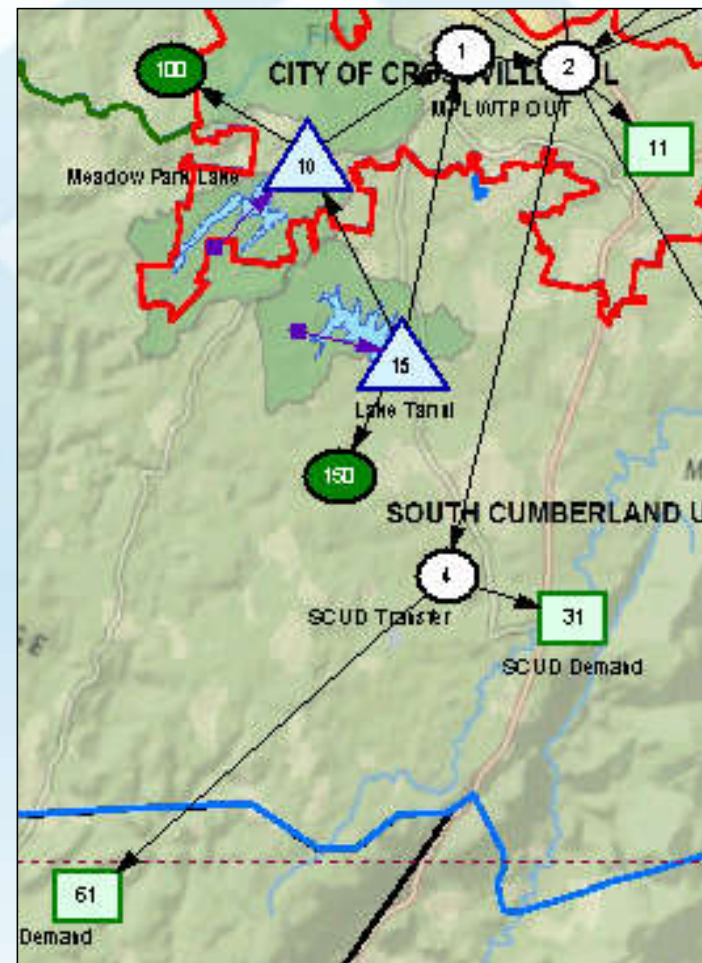
- » N/A

Interconnections

- » From Crossville = 2.174 MGD (Physical)
- » To Falls Creek Falls UD = 0.3 MGD (Physical/Institutional)

Water Supply

- » N/A



SYSTEMS MODEL WEST CUMBERLAND UD

Water Treatment (WTP)

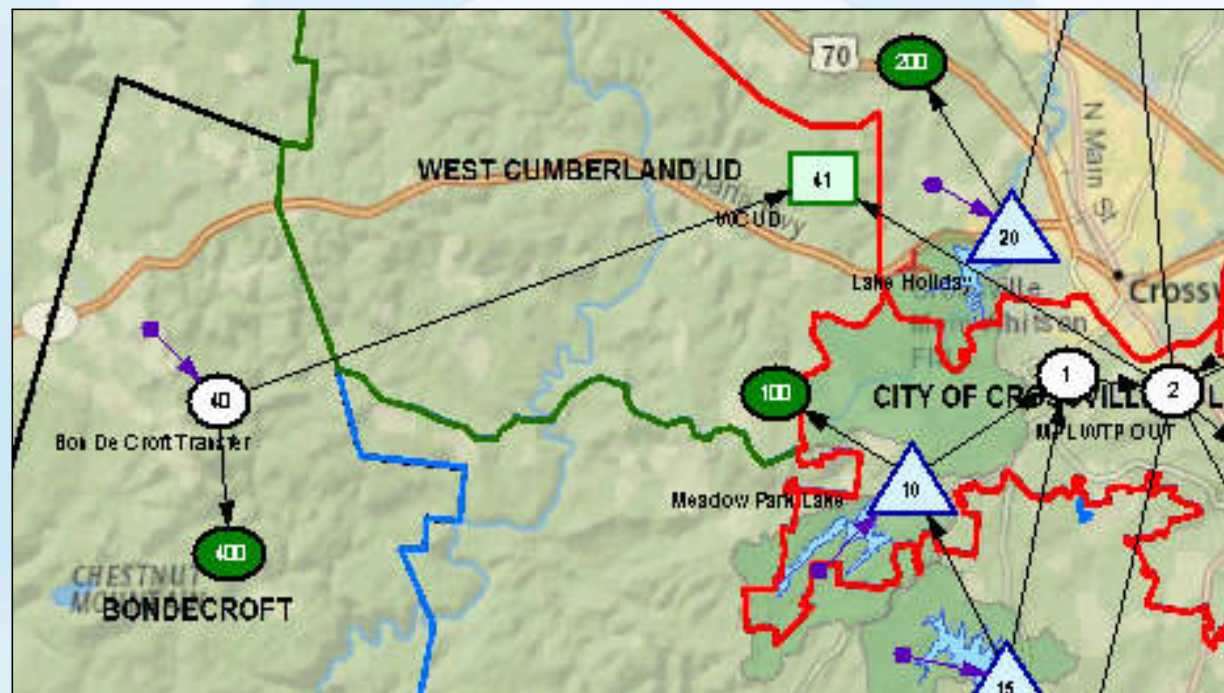
» N/A

Interconnections

- » From Bondecroft UD = 0.75 MGD (Institutional)
- » From Crossville = 0.504 MGD (Emergencies Only)

Water Supply

» N/A



SYSTEMS MODEL OUTSIDE UTILITY DISTRICTS



Grandview UD

- » Purchases from Crossville (Crab Orchard during emergencies)

Falls Creek Falls UD

- » Purchases from Crossville (through S. Cumberland)

Bondecroft UD

- » Sells to West Cumberland UD (NOTE: 0.75 MGD is available in all scenarios, Bondecroft water supply not modeled)

Town of Monterey

- » No transfer through existing connection to Crossville

