Martin Dam
Multi-Criteria Decision Analysis

Alabama Power Company

October, 2010

Challenges to Decision Making

- “Humans are quite bad at making complex, unaided decisions” (Slovic et al., 1977).
- “There is a temptation to think that honesty and common sense will suffice” (IWR-Drought Study p.vi)
- Individuals respond to complex challenges by using intuition and/or personal experience to find the easiest solution.
- Groups can devolve into entrenched positions resistant to compromise

24 Alternative Scenarios

		Alternatives																						
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Early Spring							X	X	X	X	X	X							X	X	X	X	X	X
Higher Winter Pool	Existing Base	X						X						X						X					
	1		X						X						X						X				
	2			X						X						X						X			
	3				X						X						X						X		
	4					X						X						X						X	
	5						X						X						X						X
	Fall Extension													X	X	X	X	X	X	X	X	X	X	X	X

- 24 Alternatives!
- Study Plans
- Model Outputs (Generation, Flooding, etc.)

What's the Issue?

- 24 Alternatives!
- Tremendous amount of data developed
- Disparate Datasets
  - Water Quality (Good, Bad, etc.)
  - Flood Control (% Time in Zones)
  - Habitat, Recreation (Release Rates, days)
  - Generation (MWH or $)
  - Cost ($)
- Various Interest Groups (I'm more Important)

Solution: MCDA

- Systematic Process for Analyzing Discrete Multi-Variate Decisions or Alternatives
- Creates a Standard Scoring Process
- Means of Documenting Decisions
- Iterative & Interactive Process

Decision Process Options

	Ad Hoc	Comparative Risk Assessment (CRA)	MCDA
Define Problem	Limited SH involvement	SH input after problem definition by DM or experts	SH input incorporated at project onset
Generate Altern.	DM selected	Generated w/ experts in formal manner.	Includes expert & SH involvement
Develop Criteria	Not explicitly defined	Criteria & sub-criteria defined	Criteria & sub-criteria defined by experts / SH
Relative Importance	Non-Quantitative by DM	Criteria Weights estimated by DM	Criteria Weights defined & tested by DM & SH
Rank & Selection	Opaque selection by DM	Sum Criteria Scores, Qualitative discussions	Algorithms using weights and scores

- SH – Stakeholder
- DM – Decision Maker

MCDA Applications

- Example Projects
  - **Columbia River** – Assessment of Salmon Habitat and Power Generation
  - **Glen Canyon Dam** – MCDA to evaluate Operational Alternative impacts to the Glen Canyon National Park
  - **Saluda Dam** – Assisted in evaluation of 12 guide curve alternatives on generation, recreation, pond control and habitat (Kleinschmidt project)
- EPA Document:

  "The end result of the application of multi-criteria decision analysis is a comprehensive, structured process for selecting the optimal alternative in any given situation, drawing from stakeholder preferences and value judgments as well as scientific modeling and risk analysis… The MCDA framework links technological performance information with decision criteria and weightings elicited from decision-makers, allowing visualization and quantification of the trade-offs involved in the decision-making process."

Martin Dam Goals & Objectives

- Simplify!!! Compile Results for all Alternatives
- Evaluate Criteria with a standardized scoring approach (1-5 Scores)
- Consider variable criteria weights for groups
- Develop an Objective and Defensible approach (vs. Subjective)

Major & Sub-Criteria

Martin MCDA Input Data

Major/Minor Criteria	Units	Objective	Source
Energy			
Generation & Energy	$	**Maximize** economic benefit from annual energy produced	Study 12(a)
Lake Resources			
Aquatic Vegetation/Sedimentation	Acre-Days	**Minimize** potential for increased aquatic vegetation/sedimentation	Study 12(b)
Erosion	Change in Boating Days	**Minimize** potential for increased erosion in lake	Study 12(d); Study 12(g)
Water Quality	Good/Positive, Somewhat Good, No Effect, Somewhat Bad, Bad/Negative	**Maximize** overall water quality in Lake Martin	Study 12(c)
Recreation	# of Recreation Days	**Maximize** estimated recreation days occurring on Lake Martin	Study 12(g)
Lake Property Values	% Change Over Baseline	**Maximize** estimated property values on Lake Martin	Study 12(h)
Downstream Resources			
Erosion	# of Days Over Baseline	**Minimize** potential for increased erosion downstream	Study 12(d)
Water Quality	Good/Positive, Somewhat Good, No Effect, Somewhat Bad, Bad/Negative	**Maximize** overall water quality downstream of the Project	Study 12(c)
Paddlefish Spawning	# of Days Flows > 6,000 cfs at Thurlow Dam	**Maximize** potential for spawning conditions downstream of Thurlow	Study 3
Recreation	# of Days Flows > 5,000 cfs and < 18,000 cfs at Thurlow Dam	**Maximize** potential for whitewater boating opportunities downstream of Thurlow	Study 12(f)
Reservoir Management			
Additional Days of Spill	Days of Spill at Martin Dam	**Minimize** amount of spill from Martin	Study 12(a)
Downstream Flooding	Acres	**Minimize** potential for increased flooding downstream of Martin	Study 12(a)
Thurlow Minimum Flow	# of Days Flows at Thurlow Dam > 1,200 cfs	**Maximize** days Thurlow minimum flow requirement is exceeded	Study 12(a)
Water Supply/Drought Management	Good/Positive, Somewhat Good, No Effect, Somewhat Bad, Bad/Negative	**Maximize** amount of water available in Lake	Study 12(a)
Stakeholder Preferences			
Group Preferences	Least Important – Most Important (1 to 4)	Determine **relative importance** of major criteria	Today's Meeting

Model Data Assembly

Major Criteria	Sub-Criteria	Units	Objective	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Energy																											
	Generation & Energy	$	Max	0	170,000	286,000	355,000	324,000	234,000	-159,000	-28,000	17,000	81,000	-21,000	-70,000	-270,000	-54,000	32,000	132,000	103,000	8,000	-434,000	-258,000	-242,000	-196,000	-244,000	-297,000
Lake Resources																											
	Aquatic Vegetation/Sedimentation	Acre-Days	Min	78,936	92,000	105,156	116,932	127,420	136,988	64,350	75,000	85,725	95,325	103,875	111,675	169,884	198,000	226,314	251,658	274,230	294,822	234,234	273,000	312,039	346,983	378,105	406,497
	Erosion - linked to rec days	Change in Boating Days	Min	0	5,440	13,599	21,758	24,478	27,198	19,038	24,478	32,637	40,796	43,516	46,236	29,917	35,357	43,516	51,676	54,395	57,115	48,956	54,395	62,555	70,714	73,434	76,153
	Water Quality	Good/Positive - Bad/Negative	Max	NE	NE	NE	NE	NE	NE	SB	SB	SB	SB	SB	SB	SB	SB	SB	SB	SB	SB	BN	BN	BN	BN	BN	BN
	Recreation	# of Recreation Days	Max	368,173	375,537	386,582	397,627	401,309	404,991	393,945	401,309	412,354	423,399	427,081	430,763	408,672	416,036	427,081	438,126	441,808	445,490	434,444	441,808	452,853	463,898	467,580	471,262
	Lake Property Values	% Change Over Baseline	Max	0.0%	7.7%	8.8%	9.8%	11.3%	12.6%	10.4%	10.4%	10.4%	10.4%	11.3%	12.6%	10.7%	10.7%	10.7%	10.7%	11.3%	12.6%	10.7%	10.7%	10.7%	10.7%	11.3%	12.6%
Downstream Resources																											
	Erosion	# Days Over Baseline	Min	0	12	16	23	37	52	116	126	143	147	165	176	6	18	22	29	43	58	122	132	149	153	171	182
	Water Quality	Good/Positive - Bad/Negative	Max	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	SB	SB	SB	SB	SB	SB	SB	SB	SB	SB	SB	SB
	Paddlefish Spawning	# Days Flows > 6,000 CFS	Max	0	4	5	5	19	53	52	58	65	71	83	96	0	4	5	5	19	53	52	58	65	71	83	96
	Recreation	# of Days Flows > 5kcfs and < 18kcfs	Max	55	55	55	55	55	55	63	63	63	63	63	63	56	56	56	56	56	56	64	64	64	64	64	64
Reservoir Management																											
	Addn'l Days of Spill	Days of Spill at Martin Dam	Min	0	6	10	17	22	32	85	96	113	117	134	144	3	9	13	20	25	35	88	99	116	120	137	147
	Downstream Flooding	Acres	Min	19,924	20,256	20,568	22,043	22,500	23,277	22,853	23,630	23,630	23,989	24,347	24,347	20,636	20,968	21,280	22,755	23,212	23,989	23,565	24,342	24,342	24,701	25,059	25,059
	Thurlow Min Flow	Days at Thurlow > 1200 CFS	Max	302	304	305	306	307	307	305	307	308	309	310	310	296	298	300	302	303	303	299	301	303	305	306	306
	Water Supply / Drought Mgmt.	Good/Positive - Bad/Negative	Max	NE	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG	SG

- Include Qualitative and Quantitative Data
- Assembled from Reports, Study Results, Models & Expert Opinions
- **Data drive the Results!**

Discussion of Studies

- 12-Series Studies
  - Energy & Generation (Quantitative)
  - Water Quality (Qualitative)
  - Downstream Flooding (Quantitative)

Example MCDA

- Goal: buy new car
- Criteria: Cost
- Options:
  - Car 1 ($10,000)
  - Car 2 ($20,000)
- Optimal Solution: Car 1

Example MCDA

- Goal: Buy new car
- Criteria: Cost & Safety Rating
- Preference: 50%Cost, 50%Safety
- Options:
  - Car 1 ($10,000 / 1 stars)
  - Car 2 ($20,000 / 3 stars)
- Convert Criteria to 1-5 Scale (5 best)
  - Car 1 (Cost-2, Safety 1) = 1.5
  - Car 2 (Cost-1, Safety 3) = 2.0
- Optimal Solution: Car 2

Example MCDA

- Goal: buy new car
- Criteria: Cost & Safety Rating
- Preference: 80%Cost, 20%Safety (Cost is 4x Safety)
- Options:
  - Car 1 ($10,000 / 1 stars)
  - Car 2 ($20,000 / 3 stars)
- Convert Criteria to 1-5 Scale (5 best)
  - Car 1 ([Cost]2*0.8 + [Safety]1*0.2) = 1.8
  - Car 2 ([Cost]1*0.8 + [Safety]3*0.2) = 1.4
- Optimal Solution: Car 1

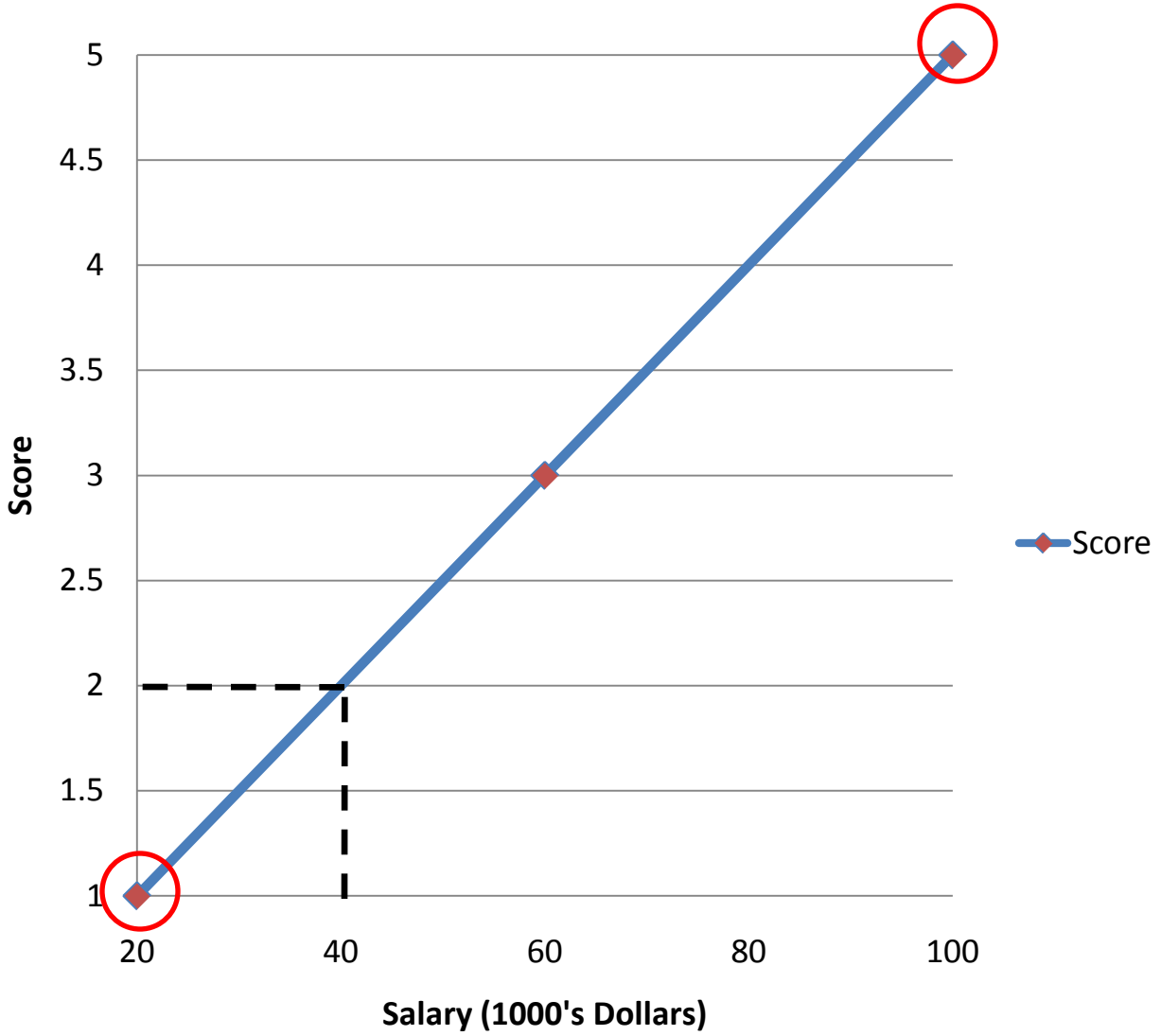
Input Data Detail

Major Criteria	Sub-Criteria	Units	Objective	1	2	3	4	5	6
Energy									
	Generation & Energy	$	Max	0	170,000	286,000	355,000	324,000	234,000
Lake Resources									
	Aquatic Vegetation/Sedimentation	Acre-Days	Min	78,976	92,020	105,189	116,936	127,445	137,052
	Erosion	Change in Boating Days	Min	0	5,440	13,599	21,758	24,478	27,198
	Water Quality	Good - Bad	Max	NE	NE	NE	NE	NE	NE
	Recreation	# of Recreation Days	Max	368,173	375,537	386,582	397,627	401,309	404,991
	Lake Property Values	% Change Over Baseline	Max	0.0%	7.7%	8.8%	9.8%	11.3%	12.6%
Downstream Resources									
	Erosion	# of Days Over Baseline	Min	0	12	16	23	37	52
	Water Quality	Good - Bad	Max	NE	NE	NE	NE	NE	NE
	Paddlefish Spawning	# of Days Flows > 6,000 cfs at Thurlow Dam	Max	0	4	5	5	19	53
	Recreation	# of Days Flows > 5,000 cfs and < 18,000 cfs at Thurlow Dam	Max	55	55	55	55	55	55
Reservoir Management									
	Additional Days of Spill	Days of Spill at Martin Dam	Min	0	6	10	17	22	32
	Downstream Flooding	Acres	Min	19,924	20,256	20,568	22,043	22,500	23,277
	Thurlow Minimum Flow	# of Days Flows at Thurlow Dam >= 1,200 cfs	Max	302	304	305	306	307	307
	Water Supply/Drought Management	Good - Bad	Max	NE	SG	SG	SG	SG	SG

Conversion of Data to 1-5 Scale

Salary	Score
20	1
60	3
100	5

Linear Interpolation Between Min-Max Values!!



Conversion of Qualitative Data

Good/Positive	**5**
Somewhat Good/Positive	**4**
No Effect	**3**
Somewhat Bad/Negative	**2**
Bad/Negative	**1**

Example – Paddlefish Spawning

Alternative	Baseline	1-ft	2-ft	3-ft	4-ft	5-ft
Winter Pool Level	0	4	5	5	19	53
Early Spring Fill	52	58	65	71	83	96
Fall Extension	0	4	5	5	19	53
Early Spring Fill & Fall Extension	52	58	65	71	83	96

Alternative	Baseline	1-ft	2-ft	3-ft	4-ft	5-ft
Winter Pool Level	1.00	1.17	1.21	1.21	1.79	3.21
Early Spring Fill	3.17	3.42	3.71	3.96	4.46	5.00
Fall Extension	1.01	1.17	1.21	1.21	1.79	3.21
Early Spring Fill & Fall Extension	3.17	3.42	3.71	3.96	4.46	5.00

Converted 1-5 Scores

Major Criteria	Sub-Criteria	Units	Objective						
Energy									
	Generation & Energy	$	Max	3.20	4.06	4.65	5.00	4.84	4.39
Lake Resources									
	Aquatic Vegetation/Sedimentation	Acre-Days	Min	4.83	4.68	4.52	4.39	4.26	4.15
	Erosion - linked to rec days	Change in Boating Days	Min	5.00	4.71	4.29	3.86	3.71	3.57
	Water Quality	Good/Positive - Bad/Negative	Max	3	3	3	3	3	3
	Recreation	# of Recreation Days	Max	1.00	1.29	1.71	2.14	2.29	2.43
	Lake Property Values	% Change Over Baseline	Max	1.00	3.44	3.80	4.11	4.57	5.00
Downstream Resources									
	Erosion	# Days Over Baseline	Min	5.00	4.74	4.65	4.49	4.19	3.86
	Water Quality	Good/Positive - Bad/Negative	Max	3	3	3	3	3	3
	Paddlefish Spawning	# Days Flows > 6,000 CFS	Max	1.00	1.17	1.21	1.21	1.79	3.21
	Recreation	# of Days Flows > 5kcfs and < 18kcfs	Max	2.05	2.05	2.05	2.05	2.05	2.05
Reservoir Management									
	Addn'l Days of Spill	Days of Spill at Martin Dam	Min	5.00	4.84	4.73	4.54	4.40	4.13
	Downstream Flooding	Acres	Min	5.00	4.74	4.50	3.35	2.99	2.39
	Thurlow Min Flow	Days at Thurlow > 1200 CFS	Max	3.00	3.50	3.75	4.00	4.25	4.25
	Water Supply / Drought Mgmt.	Good/Positive - Bad/Negative	Max	3	4	4	4	4	4

Major Criteria Weighting

- **Purpose**: Applies greater emphasis on personal areas of interest (but still allows consideration of all criteria)
- **Start** by choosing the LEAST important Major Criteria – assign it a value of '1'.
- **Then** choose how many TIMES MORE important are the other criteria (1-4 weight)
- **Rules**: Limit of 1-4, can have ties in weights, can use 0.5 increments.

Major Criteria

Energy

Lake Resources

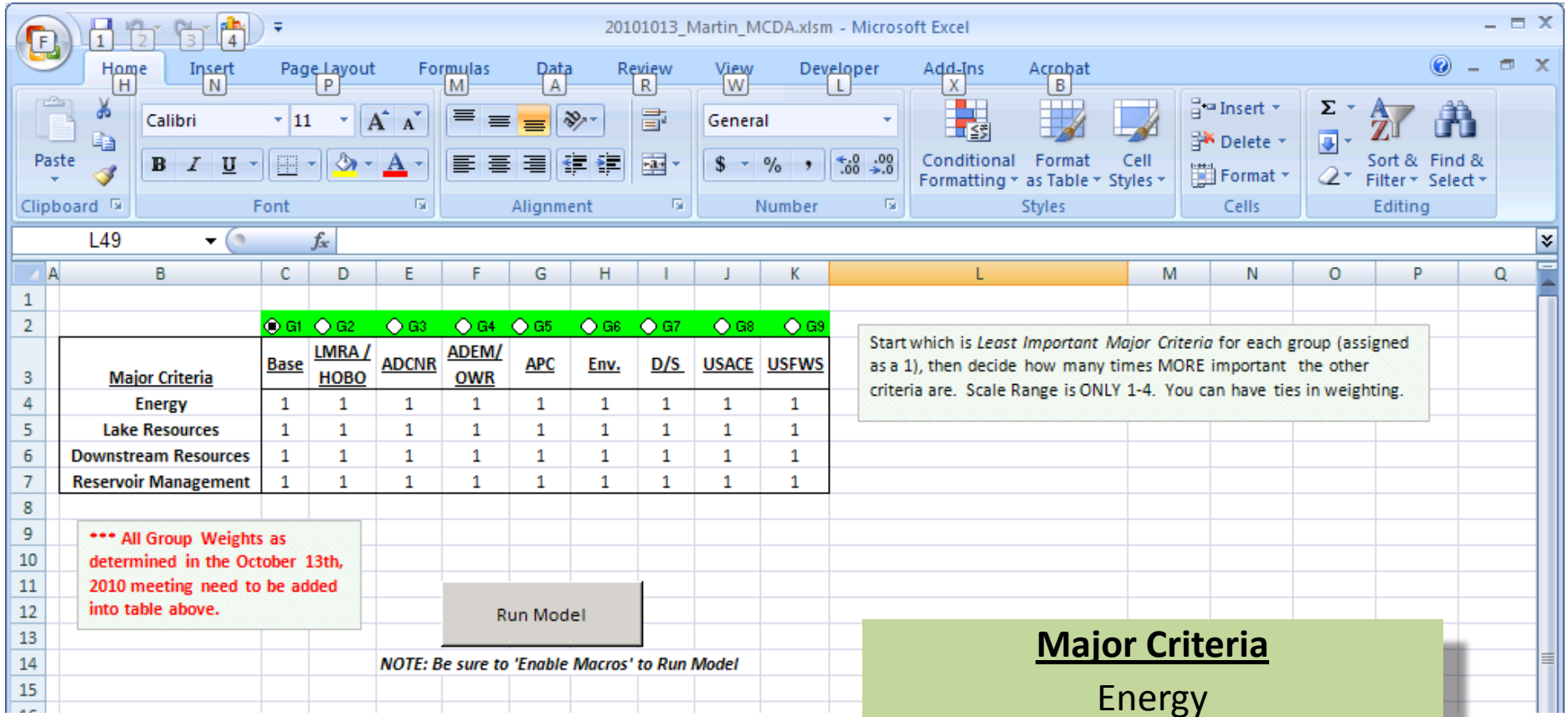
Downstream Resources

Reservoir Management

Decision Preference Groups

ID	Group	Description
1	Base	Base Case – Equal Weighting All Groups
2	LMRA/ HOBO	Lake Martin Resource Association / Homeowner and Boat Owners
3	ADCNR	Alabama Department of Conservation & Natural Resources
4	ADEM/ OWR	Alabama Department of Environmental Management, Office of Water Resources
5	APC	Alabama Power Company
6	Env.	WWF, American Rivers, Alabama Rivers Alliance
7	D/S	Downstream Interests
8	USACE	United States Army Corps of Engineers
9	USFWS	United States Fish & Wildlife Service

Model Interface



Major Criteria

Energy

Lake Resources

Downstream Resources

Reservoir Management