Modeling Assumptions of Project 184
South Fork American River

Prepared for

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INTRODUCTION

In February, 2002, El Dorado Irrigation District retained Hydrologics, Inc. to develop a model of the FERC Project 184 for relicensing of the project. Two versions of the model have been constructed. One version of the model has been developed to study the biological and geomorphology aspects of the project area. This version uses a daily time step and runs for a period of 25 years. The second version of the model was primarily developed to examine the impacts of operational changes on water supply and power generation and runs on a monthly time step for a period of 74 years.

MODEL TIME STEP AND STUDY PERIOD

Both daily and monthly time-step size was chosen because of the needs of the relicensing process. The study period currently used for the daily model is 1972-1996. This is the period covered by the hydrologic inflow data developed by Resource Insights. HydroLogics extended the monthly data to include the 1923-1996 period. The longer monthly study period includes the critical drought period of the 1930's and in most California systems, this period is used for developing operating strategies for future drought conditions. Details of the development of the hydrology are contained in the "Hydrologic Modeling Preliminary Data Final Report" for El Dorado Irrigation District by HydroLogics, Inc. dated April 3, 2002.

PHYSICAL CHARACTERISTICS

□ Schematics

The schematic of an OASIS model shows in graphic form all of the possible routes that water can flow into, through, and out of the system. It is composed of *nodes*, which represent points of interest in the system, and *arcs*, which represent conveyance from one node to another.

The schematics of project 184 include

- The portion of Echo Lake stored behind the flashboards
- Lake Aloha
- Caples Lake
- Silver Lake
- The river channels of the Silver Fork and South Fork of the American River from these reservoirs to the El Dorado Diversion Dam
- The South Fork American River from Kyburz to Folsom Lake
- The El Dorado Canal, including diversions from seven tributaries
- The El Dorado Powerhouse
- Diversion from El Dorado Forebay for consumptive use
- Diversion from Folsom Lake for consumptive use

The daily and monthly schematics are on the following pages. The schematics are made up of nodes and arcs. A node represents a point of interest in the system, like a reservoir, the confluence of two streams, or a demand. Arcs represent conveyance from one node to another. Arcs could be natural channels, canals or pipelines. The difference between the daily and monthly schematic is the representation of the area above the EID canal diversion dam near Kyburz referred to here as the upper basin. In the upper basin there are many locations that are important to the biologists and geomorphologists. These areas are represented in more detail, both in model time step and areal representation, to provide more specific information regarding flows.

Following each schematic is corresponding portions of the node and arc tables used by the model. These tables are here to be used as a reference and give the user an idea of the form and layout of the tables. In the node table, the user will input the node number, the type of node, the type of inflow the node may have and the name of the node. In the arc table, the user will input the upstream node number, the downstream node number, the name of the arc, and whether the arc has a minimum flow requirement, a maximum flow limit, and maximum reverse flow limit. The reverse flow is generally used for pipelines or canals in which water can flow in either direction.

Some of the information describing the physical characteristics and operating criteria comes from the El Dorado Hydroelectric Project Manual by PG&E. The information helped in the development of the schematics.

Figure 1
Daily Schematic

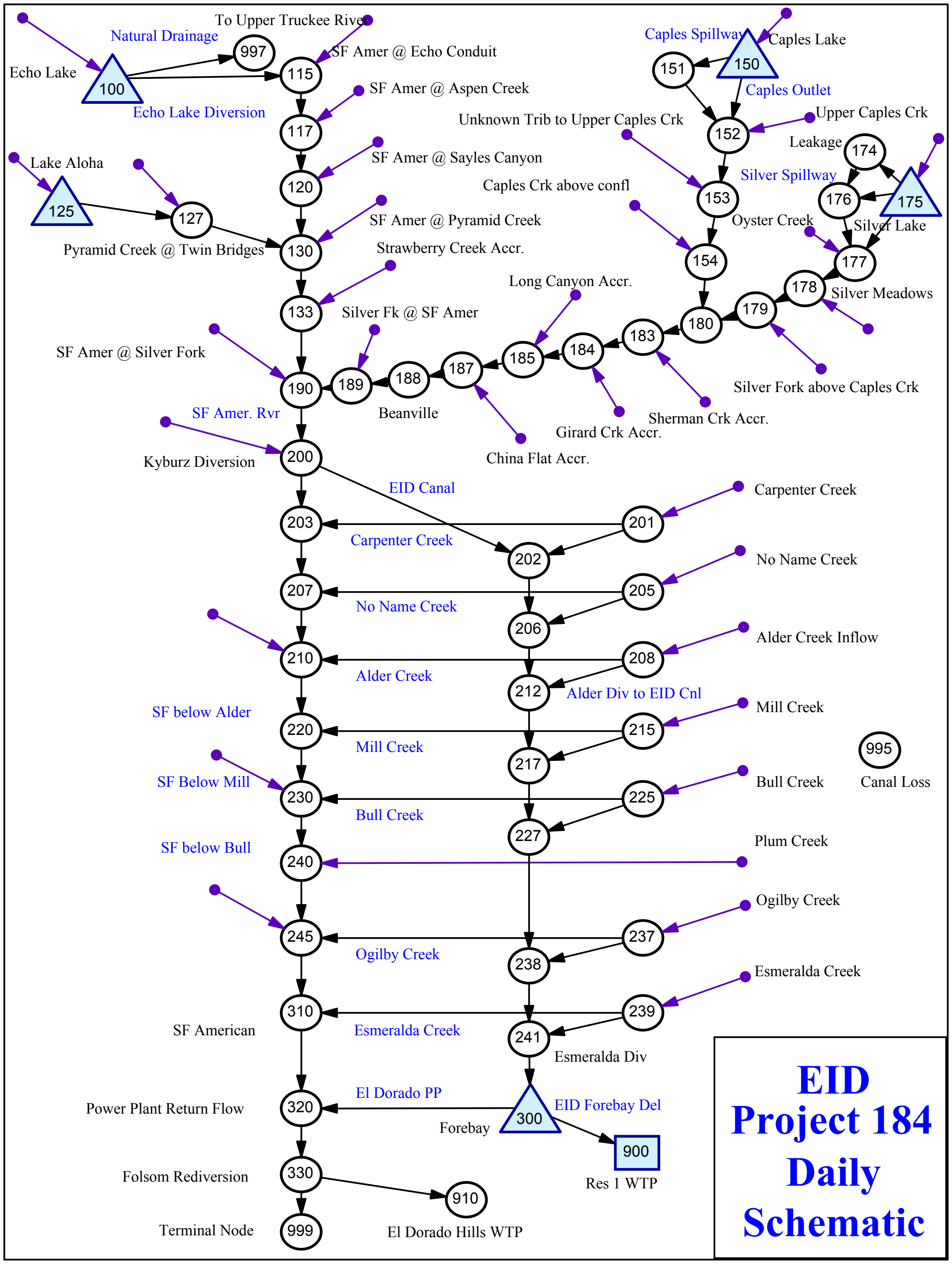


Table 1
Daily Schematic Node Table

Node Number	Type	Inflow	Name
100	Reservoir	OCL	Echo Lake
115	Junction	OCL	SF Amer @ Echo Conduit
117	Junction	OCL	SF Amer @ Aspen Creek
120	Junction	OCL	SF Amer @ Sayles Canyon
125	Reservoir	OCL	Lake Aloha
127	Junction	OCL	Pyramid Creek @ Twin Bridges
130	Junction	OCL	SF Amer @ Pyramid Creek
133	Junction	OCL	Strawberry Creek Accr.
150	Reservoir	OCL	Caples Lake
151	Junction	None	Caples Lk Outlet
152	Junction	OCL	Upper Caples Crk
153	Junction	OCL	Unknown Trib to Upper Caples Crk
154	Junction	OCL	Caples Crk above confl
174	Junction	None	Leakage
175	Reservoir	OCL	Silver Lake
176	Junction	None	Spillway
177	Junction	OCL	Oyster Creek
178	Junction	OCL	Silver Meadows
179	Junction	OCL	Silver Fork above Caples Crk
180	junction	None	Caples Creek
183	Junction	OCL	Sherman Crk Accr.
184	Junction	OCL	Girard Crk Accr.
185	Junction	OCL	Long Canyon Accr.
187	Junction	OCL	China Flat Accr.
188	Junction	OCL	Beanville Accr.
189	Junction	OCL	Silver Fk @ SF Amer
190	Junction	OCL	SF Amer @ Silver Fork
200	Junction	OCL	Kyburz Diversion
201	Junction	OCL	Carpenter Creek
202	Junction	None	EID Canal 01
203	Junction	None	SFA4
205	Junction	OCL	No Name Creek
206	Junction	None	EID Canal 2
207	Junction	None	SFA5
208	Junction	OCL	Alder Creek Inflow
210	Junction	OCL	Alder Cr
212	Junction	None	Alder Creek
215	Junction	OCL	Mill Creek
217	Junction	None	Mill Crk Div
220	Junction	None	Mill Cr
225	Junction	OCL	Bull Creek
227	Junction	None	Bull Creek Div
230	Junction	OCL	Bull Cr
237	Junction	OCL	Ogilby Creek
238	Junction	None	Ogilby Div
239	Junction	OCL	Esmeralda Creek
240	Junction	OCL	Plum Creek
241	Junction	None	Esmeralda Div
245	Junction	OCL	Ogilby Creek Conf
300	Reservoir	None	Forebay
310	Junction	None	SF American
320	Junction	None	Power Plant Return Flow
330	Junction	None	Folsom Rediversion
900	Demand	None	Res 1 WTP
910	Junction	None	El Dorado Hills WTP
995	Junction	None	Canal Loss
997	Junction	None	To Upper Truckee River
999	Junction	None	Terminal Node

Table 2
Daily Schematic Arc Table

U/S Number	D/S Number	Name	Min Flow	Max Flow	MaxRev Flow
100	115	Echo Lake Diversion	None	OCL	None
100	997	Natural Drainage	None	None	None
115	117	SFA0	None	None	None
117	120	SFA1	None	None	None
120	130	SFA2	None	None	None
125	127	Upper Pyramid Crk	OCL	None	None
127	130	Lower Pyramid Crk	None	None	None
130	133	SFA3	None	None	None
133	190	SF Amer2	None	None	None
150	151	Caples Spillway	None	None	None
150	152	Caples Outlet	None	Pattern	None
151	152	Caples Crk1	None	None	None
152	153	Caples Crk 1	OCL	None	None
153	154	Caples Crk 2	None	None	None
154	180	Caples Crk3	None	None	None
174	176	Leakage2	None	None	None
175	174	Leakage	None	None	None
175	176	Silver Spillway	None	None	None
175	177	Silver Lk Outlet	OCL	Pattern	None
176	177	Silver Crk 1	None	None	None
177	178	Silver Crk 2	None	None	None
178	179	Silver Crk 3	None	None	None
179	180	Silver Crk 4	None	None	None
180	183	Silver Fk1	None	None	None
183	184	Silver Fk 2	None	None	None
184	185	Silver Fk 3	None	None	None
185	187	Silver Fk 4	None	None	None
187	188	Silver Fk 5	None	None	None
188	189	Silver Fk 6	None	None	None
189	190	Silver Fk 7	None	None	None
190	200	SF Amer. Rvr	None	None	None
200	202	EID Canal	None	Pattern	None
200	203	Kyburz	OCL	None	None
201	202	No Name Creek Div	None	Pattern	None
201	203	Carpenter Creek	None	None	None
202	206	EID Canal 01	None	Pattern	None
203	207	SFA06	None	None	None
205	206	Carpenter Crk Div.	None	Pattern	None
205	207	No Name Creek	None	None	None
206	212	EID Canal 02	None	Pattern	None
207	210	SFA07	None	None	None
208	210	Alder Creek	None	None	None
208	212	Alder Div to EID Cnl	None	Pattern	None
210	220	SF below Alder	None	None	None
212	217	EID Canal 03	None	Pattern	None
212	995	Canal Loss	None	None	None
215	217	Mill Crk Div	None	Pattern	None
215	220	Mill Creek	None	None	None
217	227	EID Canal 04	None	Pattern	None
217	995	Canal Loss2	None	None	None
220	230	SF Below Mill	None	None	None
225	227	Bull Div	None	Pattern	None
225	230	Bull Creek	None	None	None
227	238	EID Canal 2	None	Pattern	None
227	995	Canal Loss3	None	None	None
230	240	SF below Bull	None	None	None
237	238	Ogilby Div	None	Pattern	None
237	245	Ogilby Creek	None	None	None
238	241	EID Canal 3	None	Pattern	None
238	995	Canal Loss4	None	None	None
239	241	Esmeralda Div	None	Pattern	None
239	310	Esmeralda Creek	None	None	None
240	245	SFA5	None	None	None
241	300	EID Canal 4	None	Pattern	None
241	995	Canal Loss5	None	None	None
245	310	SFA6	None	None	None
300	320	El Dorado PP	OCL	Pattern	None
300	900	EID Forebay Del	OCL	OCL	None
300	995	Canal Loss6	None	None	None
310	320	SFA7	None	None	None
320	330	SFA8	None	None	None
330	910	EID Delivery 2	None	None	None
330	999	SFA9	None	None	None

Figure 2
Monthly Schematic

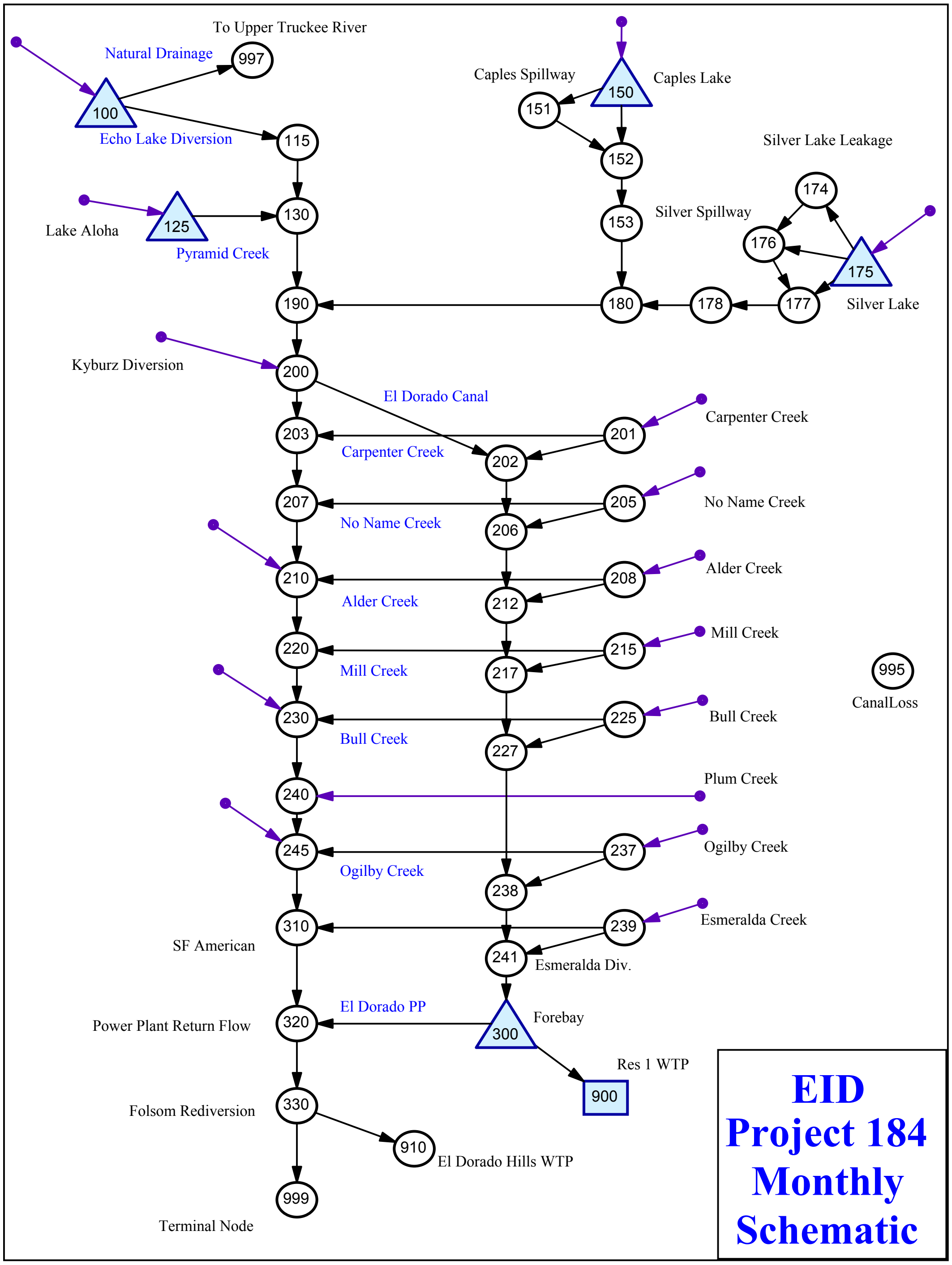


Table 3
List of Monthly Schematic Nodes

Node Number	Type	Inflow	Name
100	Reservoir	OCL	Echo Lake
115	Junction	None	SF Amer @ Apsen
125	Reservoir	OCL	Lake Aloha
130	Junction	None	Pyramid Creek
150	Reservoir	OCL	Caples Lake
151	Junction	None	Caples Spillway
152	Junction	None	Caples Creek 1
153	Junction	None	Caples Creek 2
174	Junction	None	Silver Lake Leakage
175	Reservoir	OCL	Silver Lake
176	Junction	None	Silver Spillway
177	Junction	None	SilvFork below dam
178	Junction	None	Silver Minflow
180	junction	None	Caples Creek
190	Junction	None	Silver Fork
200	Junction	OCL	Kyburz Diversion
201	Junction	OCL	Carpenter Creek
202	Junction	None	Carpenter Div
203	Junction	None	Lower Carpenter Crk
205	Junction	OCL	No Name Creek
206	Junction	None	No Name Crk Div
207	Junction	None	Lower No Name Creek
208	Junction	OCL	Alder Creek
210	Junction	OCL	Alder Cr
212	Junction	None	Alder Creek Div
215	Junction	OCL	Mill Creek
217	Junction	None	Mill Crk Div
220	Junction	None	Mill Cr
225	Junction	OCL	Bull Creek
227	Junction	None	Bull Crk Div
230	Junction	OCL	Bull Cr
237	Junction	OCL	Ogilby Creek
238	Junction	None	Ogilby Div.
239	Junction	OCL	Esmeralda Creek
240	Junction	OCL	Plum Creek
241	Junction	None	Esmeralda Div.
245	Junction	OCL	Lower Ogilby Crk
300	Reservoir	None	Forebay
310	Junction	None	SF American
320	Junction	None	Power Plant Return Flow
330	Junction	None	Folsom Rediversion
900	Demand	None	Res 1 WTP
910	Junction	None	El Dorado Hills WTP
995	Junction	None	CanalLoss
997	Junction	None	To Upper Truckee River
999	Junction	None	Terminal Node

Table 4
List of Monthly Schematic Arcs

U/S Number	D/S Number	Name	Min Flow	Max Flow	MaxRev Flow
100	115	Echo Lake Diversion	None	OCL	None
100	997	Natural Drainage	None	None	None
115	130	SF American	None	None	None
125	130	Pyramid Creek	OCL	None	None
130	190	SF American Rvr	None	None	None
150	151	Caples Spillway	None	None	None
150	152	Caples Outlet	None	Pattern	None
151	152	Spillway2	None	None	None
152	153	Caples Creek 2	OCL	None	None
153	180	Caples Creek 3	None	None	None
174	176	Leakage2	None	None	None
175	174	SilvLeak1	None	None	None
175	176	Silver Spillway	None	None	None
175	177	SilvFork below dam	OCL	Pattern	None
176	177	Silver Spillway2	None	None	None
177	178	Silver Minflow	None	None	None
178	180	Silver Fork1	None	None	None
180	190	Silver Fork 1	None	None	None
190	200	SF Amer. Rvr	None	None	None
200	202	El Dorado Canal	None	Pattern	None
200	203	SFA1	OCL	None	None
201	202	Carpenter Crk Div	None	Pattern	None
201	203	Carpenter Creek	None	None	None
202	206	EDC1	None	Pattern	None
203	207	SFA2	None	None	None
205	206	No Name Creek Div	None	Pattern	None
205	207	No Name Creek	None	None	None
206	212	EDC2	None	Pattern	None
207	210	SFA3	None	None	None
208	210	Alder Creek	None	None	None
208	212	Alder Div to EID Cnl	None	Pattern	None
210	220	SF below Alder	None	None	None
212	217	EDC3	None	Pattern	None
212	995	Loss212	None	None	None
215	217	Mill Crk Div	None	Pattern	None
215	220	Mill Creek	None	None	None
217	227	EDC4	None	Pattern	None
217	995	Loss217	None	None	None
220	230	SF Below Mill	None	None	None
225	227	Bull Div	None	Pattern	None
225	230	Bull Creek	None	None	None
227	238	EDC5	None	Pattern	None
227	995	Loss227	None	None	None
230	240	SF below Bull	None	None	None
237	238	Ogilby Div	None	Pattern	None
237	245	Ogilby Creek	None	None	None
238	241	EDC6	None	Pattern	None
238	995	Loss238	None	None	None
239	241	Esmeralda Div	None	Pattern	None
239	310	Esmeralda Crk	None	None	None
240	245	SFA7	None	None	None
241	300	EDC7	None	Pattern	None
241	995	Loss241	None	None	None
245	310	SFA8	None	None	None
300	320	El Dorado PP	OCL	Pattern	None
300	900	EID Forebay Del	OCL	OCL	None
300	995	Loss300	None	None	None
310	320	SFA9	None	None	None
320	330	SFA10	None	None	None
330	910	Rediversion	None	None	None
330	999	SFA11	None	None	None

☐ Echo Lake

Echo Lake is represented by node 100 in the schematic. Only the portion of Echo Lake which is artificially stored behind the flashboards is represented in the model. The flashboards may only be in place from April through November, so from the end of November through March the storage modeled at this node is zero. The capacity of the artificially stored water is 1943 AF. The model assumes that the natural storage in Echo Lake is constant.

Storage-area-elevation tables for Echo Lake were developed by Sea Surveyors and adapted for the model. The storage-area-elevation table below is used by the model. The entire table is located in appendix A The evaporation rate is assumed to be equivalent to rates measured at Tahoe City.

Node Number	Elevation	Elevation	Storage	Storage Units	Area	Area Units
100	7405.5	FT	0	AF	0	Acres
100	7406.2		221		0	
100	7406.4		284		250	
100	7407.5		630.9		319.8	
100	7409.5		1279.1		327.9	
100	7411.5		1942.5		335.4	

Arc 100.115 represents the diversion of water from Echo Lake into the American River basin. The capacity of the tunnel is 30 CFS. Under the water right, diversions are only allowed from September through November. The following OCL command illustrates how the imports are limited. The "*Set*" command is conditional. When the month is equal to or greater than 9 (September) and less than or equal to 11 (November) the maximum import is equal to 30 cfs. The *convert_units* function is used to convert the 30 cfs into acre feet, which is the unit used by the model. For the remaining months of the year, the maximum import is set equal to 0.

```
/* Echo Lake Operations */

 Set : max_flow100.115
 {
  condition : month >= 9  and  month <= 11
     value : convert_units{ 30 , cfs , af }

  condition : default
     value :    0
 }
```

☐ Lake Aloha

Lake Aloha is represented by node 125 in the schematic. The capacity of the reservoir is 5063 AF.

Storage-area-elevation tables for Lake Aloha were provided by PG&E converted to USGS datum. The storage-area-elevation table below is used by the model. The evaporation rate is assumed to be equivalent to rates measured at Tahoe City.

Node Number	Elevation	Elevation	Storage	Storage Units	Area	Area Units
125	8099.3	FT	0	AF	0	Acres
125	8099.9		29		0	
125	8100.5		59.4		20	
125	8101.1		92.7		59	
125	8101.7		129		63	
125	8102.3		167		67	
125	8102.9		209		70	
125	8103.4		265		256	
125	8104		429		281	
125	8104.6		605		306	
125	8105.2		793		331	
125	8105.8		998		356	
125	8106.3		1196		405	
125	8106.9		1444		419	
125	8107.5		1698		433	
125	8108.1		1961		446	
125	8108.7		2233		460	
125	8109.3		2510		473	
125	8109.9		2802		487	
125	8110.5		3099		501	
125	8111.1		3404		514	
125	8111.7		3720		528	
125	8112.3		4040		541	
125	8112.9		4375		555	
125	8113.5		4714		569	
125	8114.1		5063		583	
125	8114.2		5121		587	
125	8114.3		5179		590	

- **Caples Lake**

Caples Lake is represented by node 150 in the schematic. The capacity of the reservoir is 20494 AF without the flashboards. The flashboards are installed from April to November, bringing the capacity up to 22338 AF. The capacity of the outlet works is 350 cfs.

U/S Number	D/S Number	Units	Month	Day	Max Flow
150	152	cfs	1	1	350
150	152	cfs	12	31	350
150	152	cfs	10	1	350
150	152	cfs	9	30	350

Storage-area-elevation tables for Caples Lake were developed by Sea Surveyors. The storage-area-elevation table below is used by the model. The evaporation rate is assumed to be equivalent to rates measured at Tahoe City.

Node Number	Elevation	Elevation	Storage	Storage Units	Area	Area Units
150	7741.7	FT	0	AF	0	Acres
150	7742.7		77.5		0	
150	7743.7		169.6		50	
150	7744.7		278.5		119.2	
150	7747.7		726.6		179.3	
150	7748.7		916		198.3	
150	7750.7		1346.5		231.3	
150	7751.7		1585.7		246.2	
150	7753.7		2104		270.3	
150	7755.7		2665.1		291.2	
150	7757.7		3269.6		313.2	
150	7758.7		3588.2		323.5	
150	7759.7		3916.5		333	
150	7762.7		4958.2		361.9	
150	7766.7		6479.4		397.2	
150	7769.7		7705.5		419.7	
150	7772.7		8996.1		440.7	
150	7775.7		10349.3		461.8	
150	7777.7		11286.6		475.2	
150	7781.7		13244.1		505.1	
150	7784.7		14796.5		529.4	
150	7788.7		16979.4		562.4	
150	7790.7		18121		579	
150	7794.7		20494		605.9	
150	7796.7		21715.9		617.4	
150	7797.7		22337.7		624.3	

☐ Silver Lake

Silver Lake is represented by node 175 in the schematic. The capacity of the reservoir is 3756 AF without the flashboards. The flashboards are installed from April to October, bringing the capacity up to 8640 AF. The capacity of the outlet works is 110 cfs. The following table is OASIS input. It shows the maximum flow of the outlet works from node 175 to node 177.

U/S Number	D/S Number	Units	Month	Day	Max Flow
175	177	cfs	10	1	110
175	177	cfs	1	1	110
175	177	cfs	12	31	110
175	177	cfs	9	30	110

Storage-area-elevation tables for Silver Lake were provided by Sea Surveyors. The storage-area-elevation table below is used by the model. The entire table is located in appendix A The evaporation rate is assumed to be equivalent to rates measured at Tahoe City.

Node Number	Elevation	Elevation	Storage	Storage Units	Area	Area Units
175	7238.4	FT	0	AF	0	Acres
175	7239.07		176		50	
175	7240.07		438		266.6	
175	7241.07		709		275.9	
175	7242.07		989		285.1	
175	7243.07		1279		294.3	
175	7244.07		1578		303.7	
175	7245.07		1887		314.5	
175	7246.07		2207		327.4	
175	7247.07		2541		341.5	
175	7248.07		2890		357.1	
175	7249.07		3256		373.7	
175	7250.07		3637		388.9	
175	7251.07		4033		403.3	
175	7252.07		4444		418	
175	7253.07		4869		432.8	
175	7254.07		5309		446.1	
175	7255.07		5762		456.8	
175	7256.07		6223		465.2	
175	7257.07		6692		472.6	
175	7258.07		7168		479.7	
175	7259.07		7651		487	
175	7260.07		8142		494.3	
175	7261.07		8640		501.6	

□ Evaporation

At Echo, Aloha, Caples, and Silver Lakes, we applied the average evaporation rate measured at Tahoe City, California (National Weather Service station number 048758). Because of the large number missing data in the record, we adjusted the evaporation rate slightly in October (from 1.5 to 1.7 inches) and November (from 0.0 to 0.3 inches).

Node Number	Units	Factor	Month	Day	Evaporation
1001	Inch	1	10	1	1.7
1002			10	31	1.7
1003			11	1	0.3
1004			11	30	0.3
1005			12	1	0
1006			12	31	0
1007			1	1	0
1008			1	31	0

1009		2	1	0
1001		2	29	0
1001		3	1	0
1001		3	31	0
1001		4	1	0
1001		4	30	0
1001		5	1	4.5
1001		5	31	4.5
1001		6	1	5.3
1001		6	30	5.3
1001		7	1	6
1002		7	31	6
1002		8	1	5.4
1002		8	31	5.4
1002		9	1	3.2
1002		9	30	3.2

☐ Silver Fork and South Fork American River above Kyburz

The daily model represents accretions at several locations on both the Silver Fork and South Fork American Rivers. Each inflow represents the accretion between the node where the accretion is represented and the accretion(s) directly upstream. This is possible because we know the unimpaired flow at each location and simply subtract the unimpaired flow at the upstream location(s) from the unimpaired flow at the location of interest. We do this operation with OCL. The following equation calculates the accretion for the Silver Fork American at China Flat.

```
/* Silver Fork Accr. at China Flat */

Set : inflow187
{
  value : timesers(unimpaired/flow187) - timesers(unimpaired/flow185)
}
```

The node that represents China Flat is node 187. The inflow at node 187 is set equal to the unimpaired time series flow data for China Flat minus the unimpaired time series flow data for Long Canyon Creek.

Other than the reaches immediately below each dam, the monthly model does not provide any information about the flows above Kyburz. Therefore, the monthly schematic represents these river reaches very simply. All local inflow to the river above Kyburz, other than the inflow to each reservoir, is simulated by a single inflow point at node 200.

☐ South Fork American River below Kyburz

We are simulating flow in each of the 7 tributaries that have diversions into the El Dorado Canal. Furthermore, we are simulating flows from Plum Creek and we have distributed the rest of the local inflow to 3 points. While the 7 tributaries with diversion points are useful for this study, Plum Creek and the other inflow points are for temperature modeling. We represent these flows in this way for consistency with a study concurrently being done for the relicensing of Project 184.

☐ El Dorado Canal

El Dorado Diversion Dam is represented by node 200. The diversion into the canal from the South Fork American River is shown by arc 200.202. The maximum flow limits in the input tables reflect the change in canal capacity throughout the length of the canal. The modeled capacity of this arc is 163 CFS.

U/S Number	D/S Number	Units	Month	Day	Max Flow
200	202	cfs	1	1	163
200	202	cfs	9	30	163
200	202	cfs	10	1	163
200	202	cfs	12	31	163

Diversion from the tributaries are also modeled in the same manner. The diversion into the canal from Carpenter Creek is represented by the arc from node 200 to 202 and is limited to 10 cfs as shown in the table below. Each tributary that can divert water into the canal has a diversion limit.

U/S Number	D/S Number	Units	Month	Day	Max Flow
201	202	cfs	1	1	10
201	202	cfs	12	31	10
201	202	cfs	10	1	10
201	202	cfs	9	30	10

Seepage losses along the El Dorado Canal are significant. We chose to model a constant loss rate per canal distance. However, the model operation would be unrealistic if the full seepage were to occur when the flow in the canal is near zero. Specifically, we did not want the model to show reservoir releases that served no more purpose than to maintain losses in the canal. Therefore, in each segment of the canal we used a modified constant loss rate as follows:

(Loss in canal segment-CFS) = 0.25 * (Flow into canal segment-CFS)
(Loss in canal segment-CFS) < (Loss rate-CFS/mile) * (length of canal segment-miles)

Thus, the loss rate is constant unless the flow in the canal segment is very low, in which case the loss rate is 25% of the flow in the segment. This is realistic in that we expect the losses to be lower when the flow into the canal is lower. However, the selection of a formula of 25% of the flow in each canal segment is arbitrary – not based on any observed data. This formula was chosen merely in order to prevent strange model behavior during low flows.

Mike Wright of EID told us the length of the canal between points:

Canal reach	Model Arc Numbers	Distance (miles)	Maximum loss (CFS)
Diversion Dam to Alder Creek Siphon	200.202, 202.206, 206.212	4.06	1.62
Alder Creek Siphon to Mill Creek	212.217	0.81	0.32
Mill Creek to Bull Creek	217.227	2.40	0.96
Bull Creek to Ogilby Creek	227.238	3.87	1.55
Ogilby Creek to Esmeralda Creek	238.241	0.73	0.29
Esmeralda Creek to Forebay	241.300	9.54	3.81
TOTAL		21.40	8.56

Mike Wright stated that he believed the maximum loss in the canal totaled about 7 to 8 CFS. However, our analysis of records showed periods when the loss was computed to be about 11 CFS. We compromised by using a loss factor of 0.4 CFS/mile, which results in a total loss of about 8.56 CFS.

We modeled the capacity of the diversions from the 7 tributaries to be equal to the maximum diversion allowed by the water rights.

☐ **Forebay**

Node 300 represents the El Dorado Forebay. We specified in the model that the storage in this node would always be constant. This is because the forebay is too small to show significant month-to-month or even day-to-day operations.

☐ **El Dorado Powerhouse**

Arc 300.320 represents the El Dorado Powerhouse. We placed a maximum flow of 163 CFS through this arc to represent the powerhouse capacity.

U/S Number	D/S Number	Units	Month	Day	Max Flow
300	320	cfs	1	1	163
300	320	cfs	12	31	163
300	320	cfs	10	1	163
300	320	cfs	9	30	163

☐ **Diversion from El Dorado Forebay**

Node 900 represents the EID's diversion of water for consumptive use from El Dorado Forebay. We placed a time series demand which varies from 10,050 af annually to 15,081 af annually. The demands were developed for the 2005 level of demand by Chuck Abraham using the Abraham model.

☐ Diversion from Folsom Lake

Node 910 represents EID's diversion of water for consumptive use from Folsom Reservoir. We placed a constant demand of 17,000 AF per year on this node. This represents full use of EID's water right. Therefore, the model runs all represent a scenario where EID *is* trying to divert its entire water right.

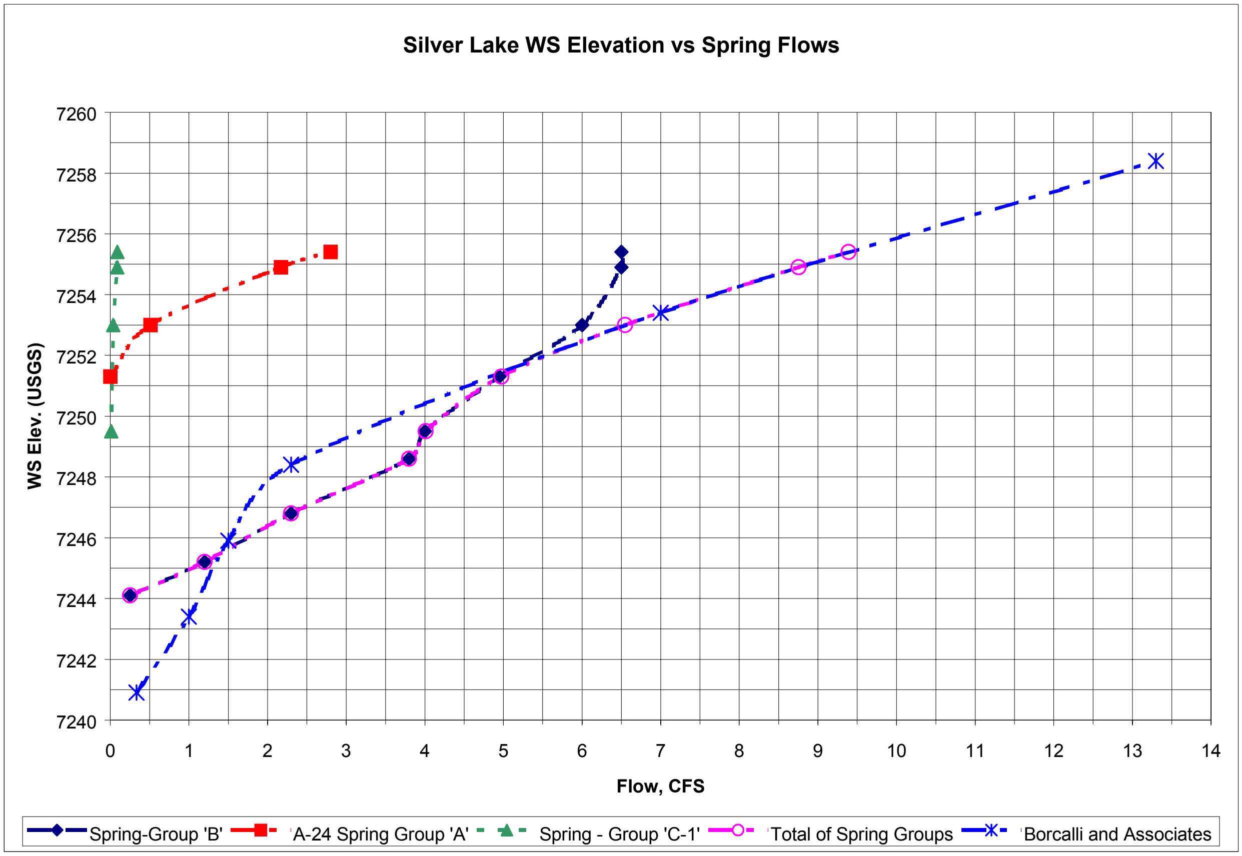
The monthly pattern of demand comes from a document labeled *Table 7.1: EID Operation Scenario: Utilization of Supplemental Water from PG&E Sources: 1995 through 2013 Demand Levels*. The pattern we used is identified as *1977 Rediversion* for the 2013 demand level. 1977 represents the most critical year in the period of record.

☐ Silver Lake Leakage

A significant amount of seepage or leakage occurs around Silver Lake Dam. Borcalli and Associates has computed the seepage rate as a function of reservoir water-surface elevation. We programmed this function into the model, such that the leakage (and only the leakage) is represented by arc 175.174. The flow in this arc is based upon the reservoir water-surface elevation at the beginning of the month. The seepage returns to the river below the reach where minimum in-stream flows are mandated.

Andrew Price has collected some recent data represented in the graph below. HydroLogics combined Andrew Price's measured flow at Spring Group 'B', Spring Group 'A', and Spring Group 'C-1' to come up with a total measured leakage. Then, the total was compared to the water surface elevation vs. leakage function developed by Borcalli and Associates. The comparison shows that the data collected by Andrew Price verifies the relationship developed by Borcalli and Associates. At water surface elevations greater than about 7251', the relationship is strongly correlated. Water surface elevation 7251' is equivalent to 4033 acre feet which is roughly half full.

Figure 3
Silver Lake Water Surface Elevation vs Spring Flows



From the file Silver_Lake.ocl, the following formulation is how the Silver Lake leakage is modeled.

/ Substantial leakage occurs around Silver Lake Dam. The function*
*of estimated leakage is stored in a LOOKUP table. */*

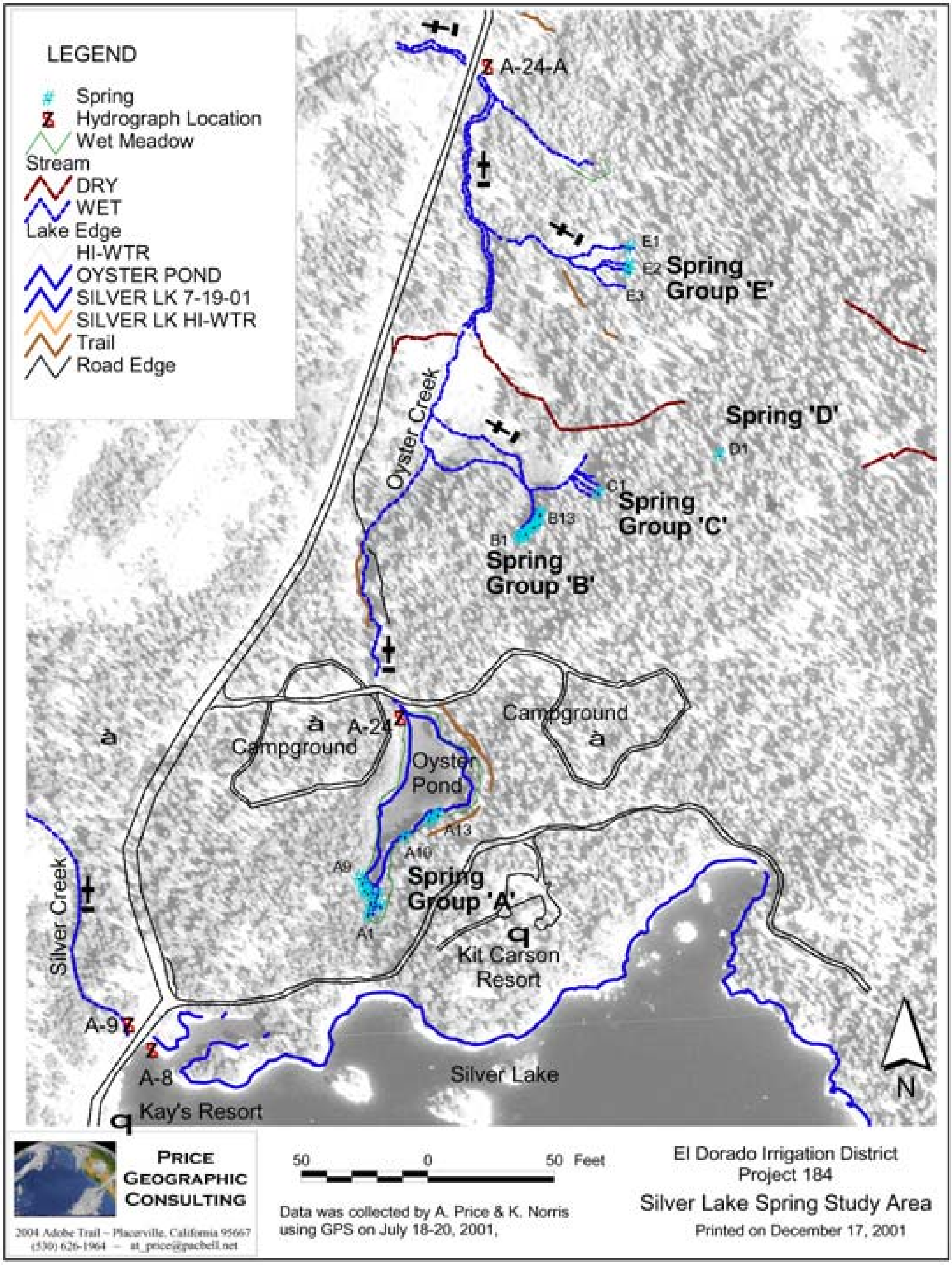
***SET**: Stage175 { value: elevation175-stor_to_elev{175,0} }*

***CONSTRAINT** SilverLakeLeakage:*
{   dFlow175.174 = Lookup{ SilverLakeLeakage, Stage175 } }

The "*Set*" command above sets the variable *Stage175* equal to the water surface elevation of Silver Lake. The "*Constraint*" command is named "SilverLakeLeakage".   The constraint sets the flow in the arc from node 175 to node 174 equal to a value in the following lookup table based on the water surface elevation (*Stage175*). The lookup table name is SilverLakeLeakage. The **independent** variable in the table is *Stage175* and the **dependent** variable is leakage in acre feet.

Name	Interp	Independent	Dependent
SilverLakeLeakage	Interp	0	0
SilverLakeLeakage		8	114.24
SilverLakeLeakage		10	171.46
SilverLakeLeakage		13	294.7
SilverLakeLeakage		15	430
SilverLakeLeakage		25	1170.3

If the stage is not equal to one of the independent values, the database will interpolate. The following page shows the location of the measured seepage.


LEGEND
Spring
Hydrograph Location
Wet Meadow
Stream
DRY
WET
Lake Edge
HI-WTR
OYSTER POND
SILVER LK 7-19-01
SILVER LK HI-WTR
Trail
Road Edge
A-24-A
E1
E2
E3
Spring Group 'E'
Spring 'D'
D1
Oyster Creek
C1
Spring Group 'C'
B13
B1
Spring Group 'B'
Campground
A-24
Campground
Oyster Pond
A13
A10
A9
Spring Group 'A'
A1
Kit Carson Resort
Silver Creek
A-9
A-8
Silver Lake
Kay's Resort
N
PRICE GEOGRAPHIC CONSULTING
2004 Adobe Trail ~ Placerville, California 95667
(530) 626-1964 ~ at_price@pacbell.net
50 0 50 Feet
Data was collected by A. Price & K. Norris using GPS on July 18-20, 2001,
El Dorado Irrigation District
Project 184
Silver Lake Spring Study Area
Printed on December 17, 2001

OPERATIONAL CONSTRAINTS AND TARGETS

☐ Minimum Flow Requirements

FERC mandated minimum flow requirements exists below Lake Aloha, Caples Lake, Silver Lake and Kyburz diversion dam. We have used OCL to implement these minimum flow requirements. The commands in this section come from the ops_criteria.ocl file.

■ Caples Lake

The Caples Lake minimum flow requirement is 5 cfs or the natural inflow, whichever is less. The OCL formulation of the requirement is as follows:

Set Caples_Min: min_flow152.153 { value: min{ inflow150, convert_units{5,cfs,af} } }

■ Silver Lake

The Silver Lake minimum flow requirement is 2 cfs or the natural inflow, whichever is less. The OCL formulation of the requirement is as follows:

Set Silver_Min: min_flow175.177 { value: min{ inflow175, convert_units{2,cfs,af} } }

■ Lake Aloha

Likewise, the Lake Aloha minimum flow requirement is 2 cfs or the natural inflow, whichever is less. The OCL formulation of the requirement is as follows:

Set Pyramid_Min: min_flow125.127 { value: min{ inflow125, convert_units{2,cfs,af} } }

■ South Fork American River at Kyburz

The South Fork American River at Kyburz minimum flow requirement is more complicated. The requirement varies with hydrologic year type. The year type for the FERC-mandated minumum flows is based upon DWR's forecast of unimpaired inflow to Folsom Reservoir from the South Fork of the American River between April and July. The water year is determined on April 1 and revised on May 1 using updated information.

Code	Year Type	Flow in South Fork as percent of Normal
1	Wet	> 125
2	Above-Normal	100-125
3	Below-Normal	75-100
4	Dry	50-75
5	Critical	< 50

In order to simulate for the period 1923-1996, we need to know what the forecasts would have been with historical hydrologic conditions and current forecasting methodology. In its planning models, DWR uses a forecast for the *total* unimpaired inflow to Folsom Reservoir (*not* just the South Fork). The time-series of these assumed historical forecasts is available for water years

1922-1994. These forecasts are supposed to be based on a consistent methodology. The April forecast is made with a 75% chance of exceedence, and the May forecast is made with a 50% chance of exceedence.

We chose to base our year types upon the DWR modeling data since it comes from a widely accepted source and uses a consistent methodology. We had to assume that the inflow to the total basin would result in the same water-year type as if we had used the inflow from only the South Fork. Furthermore, these forecasts are stated as inflow for the *remainder of the water year* – through the end of September. We had to subtract some value for the flow in August in September in order to get a value for April-July. The August-September flow would of course be unknown to the operators, although they would have some idea of the flow, since they have a forecast of the flow through the end of September. We used least-squares regression to develop this formula:

$$y = 0.000008x^2 + 0.0077x + 1$$

where x=Actual unimpaired flow Apr-Sep
y=Actual unimpaired flow Aug-Sep

However, the data for water years 1995 and 1996 are not found in the DWR models. Therefore, for those two years we applied the forecasted values that were actually made at the time. We know that the actual forecasts were developed with different assumptions than the modeling forecasts. We analyzed the actual forecasts to the modeling forecasts for the years 1980-1994. We found that for the May forecasts, there are differences between these values, but the central tendency is that the two are equal. For the April forecasts, the most important difference is that the modeling forecasts were made for a 75% probability of exceedence, and the actual forecasts were made with a 50% probability of exceedence. Therefore, we used least-squares regression to develop this formula:

$$y = 0.7084x + 150$$

where x=Actual forecast from Apr. with 50% prob. of exceedence
y=Modeling forecast from Apr. with 75% prob. of exceedence

After we determine what year type we have, we set the minimum flow requirement based on the current year type. The following is the OCL code that does this in *ops_criteria.ocl*.

```
/* El Dorado Diversion Dam near Kyburz */
/*Bypass Period      Minimum Flow     Minimum Flow
                     (Normal Year)    (Dry Year)
  11/01 to 08/31       50 cfs           18 cfs
  09/01 to 09/30       38 cfs           10 cfs
  10/01 to 10/31       43 cfs           15 cfs     */

/* A normal year is defined as any year when the South Fork American River annual runoff, at the
   inflow to Folsom Reservoir, as forecasted on April 1 and corrected on May 1 by the California
   Department of Water Resources, is greater than 50 percent of the 50-year average.  All other
   years are defined as dry.
```

```
 However, we should translate that from the 5-category year types defined for other criteria
      1  W    > 1.25
      2  AN   1.25-1.00
      3  BN   1.00-0.75
      4  D    0.75-0.50
      5  C    < 0.50
  Thus, for El Dorado Diversion Dam, "Dry" is a year type of 5, and year types 1-4 are
  considered "Normal".
*/

:Substitute: [Forecast_Avg] = 1261000

set : YrType
{
   condition W : timesers(FOLSOM/FORECAST-DWRSIM) > 125
           value : 1

   condition AN: timesers(FOLSOM/FORECAST-DWRSIM) > 100
           value : 2

   condition BN: timesers(FOLSOM/FORECAST-DWRSIM) >  75
           value : 3

   condition D : timesers(FOLSOM/FORECAST-DWRSIM) >  50
           value : 4

   condition C : default
           value : 5
}

set : min_flow200.203
{
   condition normal : YrType < 5
   {
      condition Oct-NORM     : month = 10
                  value : convert_units{ 43 , cfs , af }

             condition Nov-Aug-NORM : month > 10 or month < 9
                      value : convert_units{ 50 , cfs , af }

             condition Sep-NORM     : month = 9
                      value : convert_units{ 38 , cfs , af }
   }

   condition dry    : YrType = 5
   {
      condition Oct-DRY      : month = 10
                  value : convert_units{ 15 , cfs , af }

             condition Nov-Aug-DRY  : month > 10 or month < 9
                      value : convert_units{ 18 , cfs , af }

             condition Sep-DRY      : month = 9
                      value : convert_units{ 10 , cfs , af }
   }
}
```

☐ Weight Factors

OASIS relies on weights to drive common-sense operating decisions. Water flows from uses with higher weights to uses with lower weights. For example, if the minimum flow below a reservoir has a higher weight that that assigned to water kept in storage, then OASIS will cause water to be released from storage to meet the minimum flow. Weights are inut in three tables; Weight:Arc, Weight:Demand, and Weight:Storage. Weights are also input as penalties for not meeting OCL targets in target fommands. In almost all cases, the weighting scheme is ordinal, simple and easy to understand.

OASIS allows for four standard reservoir zones defined be rule curves.

1. Zone A, 0 to dead storage, which is defined as the storage below which releases may not be made. This is assigned a very high weight so that it is never used to meet downstream demands, although evaporation losses can still occur.
2. Zone B, dead storage to lower rule. Minimum releases, instream flows and demands are often met from this zone.
3. Zone C, lower rule to upper rule. Storage is typically in this zone when there is sufficient water to meet all demands and flow targets.
4. Zone D, typically flood storage.

☐ OCL Input Data

There are 7 Ocl files needed to run the OASIS model of Project 184. *Main.ocl* is the first file read. It defines substitute values which make the remainder of the OCL files more readable, sets the location of the pattern , lookup, and timeseries data referred to in the OCL files, and sets the order for reading the remaining files. A listing of the OCL file can be found as included files in *Main.ocl*.

Each OCL file can be thought of as a subroutine called by main.ocl. Additional OCL files may be added or subtracted depending upon assumptions of any particular study. The difference between a subroutine and an OCL file is that the order in which OCL files are used isn't important since all instructions are weighted and the highest weighted items are preferred. Order maters only in terms of defining a variable before it is used. The following is a list and brief description of each of the OCL files currently in use:

main.ocl — The main OCL file which contains information about databases used, substitute values, user defined variables and additional OCL files used.

inflow.ocl — Calculates the inflows at each inflow location based on the unimpaired inflow data contained in the HEC-DSS database. For monthly runs the database is called *monthly_basedata.dss*. For daily runs the database is called *daily_basedata.dss*

ops_criteria.ocl	Contains instructions for determining minimum flow requirements below Lake Aloha, Caples Lake, Silver Lake and for the South Fork American River below the EID diversion dam near Kyburz.
demands.ocl	Contains instructions for meeting demands met from Forebay. Currently, the model is instructed to use only natural flow or storage releases from Silver lake to meet consumptive use demands.
echo_lake.ocl	Contains instructions for importing water from September through November, for removing flashboards from November through March, and for deciding when to put the flashboards back up after April depending upon hydrologic conditions.
caples_lake.ocl	Contains instructions for removing flashboards from October through March. The file also contains storage targets depending upon hydrologic conditions.
silver_lake.ocl	Contains instructions for removing flashboards from November through March, calculates leakage from the lake based on reservoir stage, enforces the Amador County Settlement Agreement and sets storage targets depending upon hydrologic conditions.

☐ **Amador County Settlement Agreement**

The Amador County Settlement Agreement is an agreement between El Dorado Irrigation District and Amador County regarding the operation of Silver Lake. Amador County's main concern is to ensure that EID does not reduce the lake levels at Silver Lake during the May 1 to Labor Day recreation season.

The following is an excerpt from the agreement, (Article 3, page 4):

To protect Silver Lake's summer recreational uses and scenic beauty, EID or the other El Dorado Party shall not release prior to Labor Day of each year water from the lake for consumptive use, power production, rediversion or other purposes excluding any non-discretionary releases required by FERC License 184 or the State Division of Safety of Dams.

The following italicized OCL code is used to model the agreement. The Silver lake release is conditional. During the May through September period, indicated by *condition : month >= 5 and month<=8*, there is a 1000 point penalty for releases above or below the minimum flow requirement. For the remainder of the year, indicated by the *condition : default*, there is a 1000 point penalty for not meeting the minimum flow requirement, but no penalty for releasing more than the minimum flow requirement

```
/* Amador County Settlement agreement intends to prevent releases other than to meet
   minimum flow requirements, spills and leakage from Silver Lake from May through
   August.  The following commands are to comply with the agreement. */
```

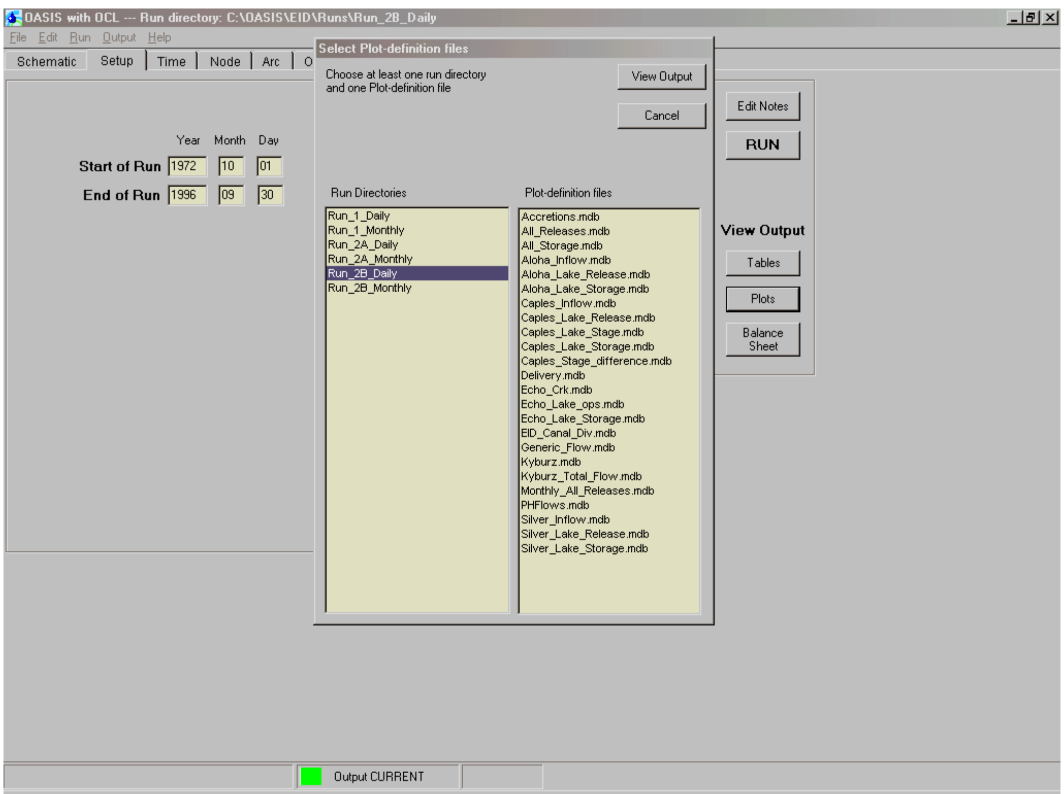
```
Target Silver_Lake_Release : dflow175.177
{

  condition : month >= 5 and month <=8
   priority: 1
   penalty+: 1000
   penalty-: 1000
      value: min_flow175.177

  condition : default
   priority: 1
   penalty+: 0
   penalty-: 1000
      value: min_flow175.177

}
```

MODEL OUTPUT

The Graphical User Interface (GUI) controls the operation of post-processors that can provide results of the studies in the form of either plots or data tables. Either can be accessed from the *Setup* page of the GUI.

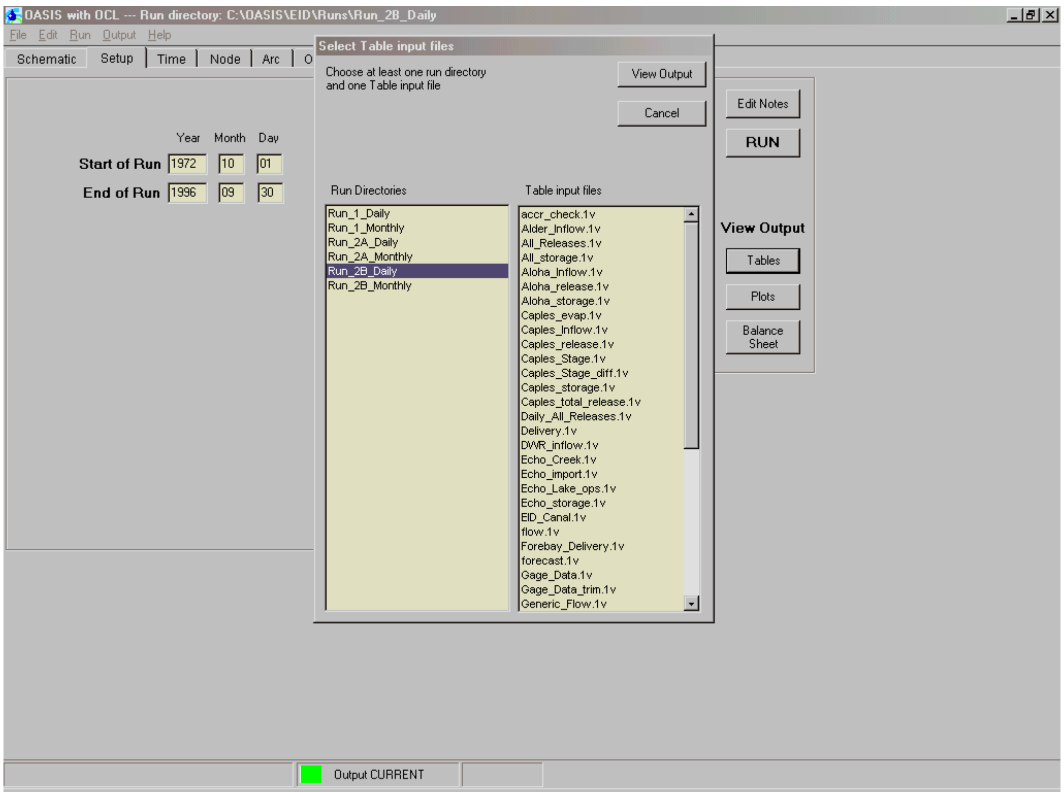
☐ **Plots**

To generate plots of the output click on the *Plots* button on the *Setup* page. A window will pop up with a list of the available Runs on the left and a list of the available plots are on the right. The following screen capture shows the window. The user can select several runs and several plots at once using the *shift* or *ctrl* keys on the keyboard. After clicking the *View Output* button the plots will be generated. Plots often contain more than one trace. For example, the user may want to look at the simulated flow below Caples Lake versus a minimum flow requirement below Caples Lake to make sure the release is meeting the flow requirement.. This will work fine for an individual run. If, however, if more than one run is selected, only the first trace of each run will plot. In this case, the simulated flow below Caples Lake will plot for both studies, but the minimum flow requirement will not plot.



☐ **Tables**

To generate tables of the output click on the *Tables* button on the *Setup* page. A window will pop up with a list of the available Runs on the left and a list of the available tables on the right. The following screen capture shows the window. The user can select several runs and several tables at once using the *shift* or *ctrl* keys on the keyboard. After clicking the *View Output* button the tables will be generated. Unlike the Plots all the information contained in the tables will be generated.



All of the plots and tables can be modified and new ones can be created. See Chapter 5 of the User Manual for details. One of the advantages we have is we can generate output in tables or columns and in comma-delimited formats for easy importing to spreadsheets.