Hawaii WWTP Energy Audits
“A Virtual Tour”

February, 2010

Today's Agenda

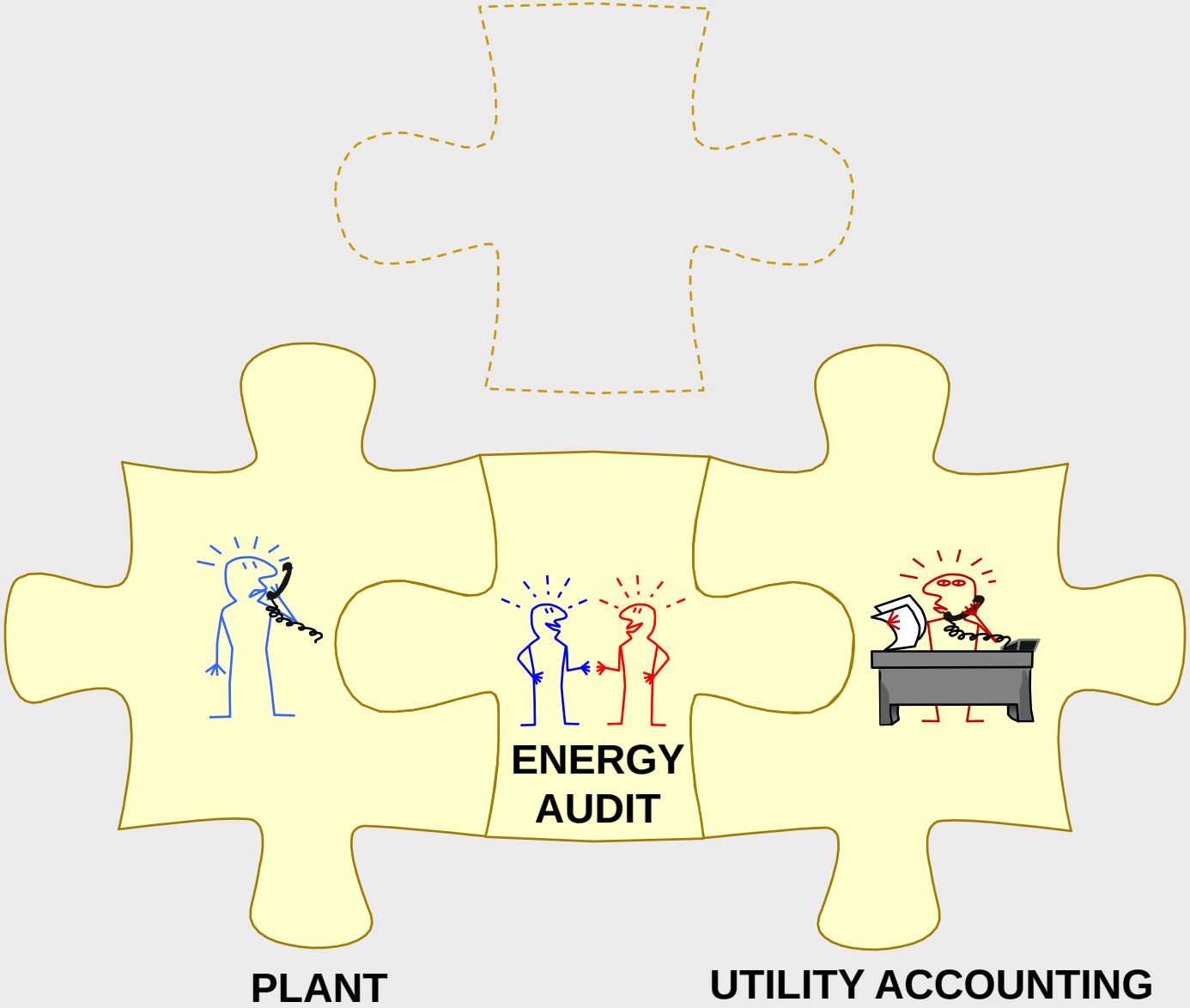
- The energy audit process
- 4 plants 4 stories
- WWTP "Virtual Tour"
- Energy audit do's and don'ts
- Conclusions

Benefits of Energy Audit?

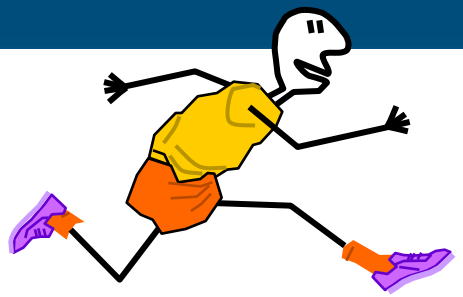
- Improve understanding of processes
- Bridge energy use and accounting
- Gain comprehension of utility bills
- Clarity of energy use and effects
- Improve resource utilization
- Enhance relationship with utility provider
- Improve relationship with rate payers

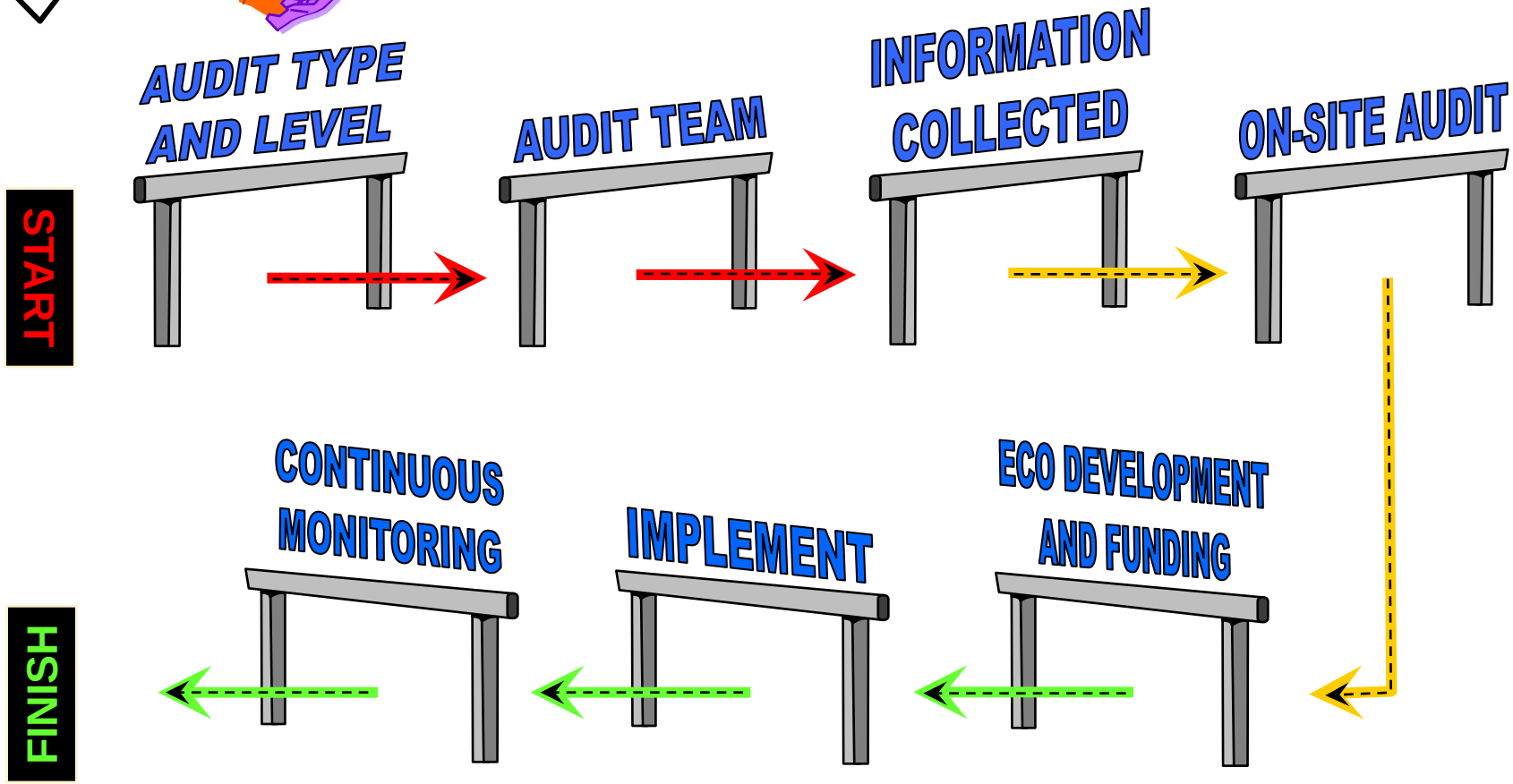
Benefits of Energy Audit?

- Recognize your successes
- Goal development
- Reduce operating costs
- Prepare for a renewable future
- Three legged stool: energy efficiency, energy conservation and renewable energy generation


ENERGY
AUDIT
PLANT
UTILITY ACCOUNTING

Energy Audit - Road Map





Audit Sequence – Define Audit Type

- Many types of energy audits
  - Equipment audit

    (i.e. pumps, compressed air, lighting)
  - Process audit

    (i.e. aeration, hydraulic capacity, or overall treatment process)

Audit Sequence – Define Level of Audit

- Three basic levels
  - **LEVEL I:** preliminary energy use evaluation, identify low-cost/no-cost measures, identify potential capital improvements that merit further analysis
  - **LEVEL II:** more detailed facility survey and energy analysis, develop energy use breakdown, identify practical improvements that meet owners constraints and economic criteria
  - **LEVEL III:** detailed analysis of capital-intensive modifications, requires more field data and engineering analysis, detailed cost and savings information developed for decision making

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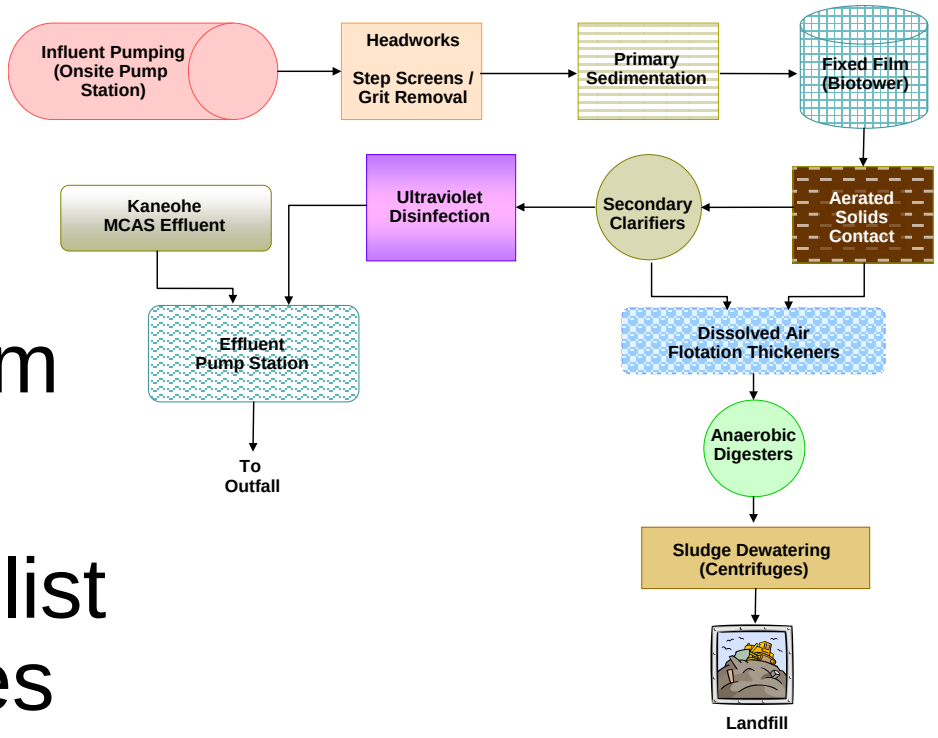
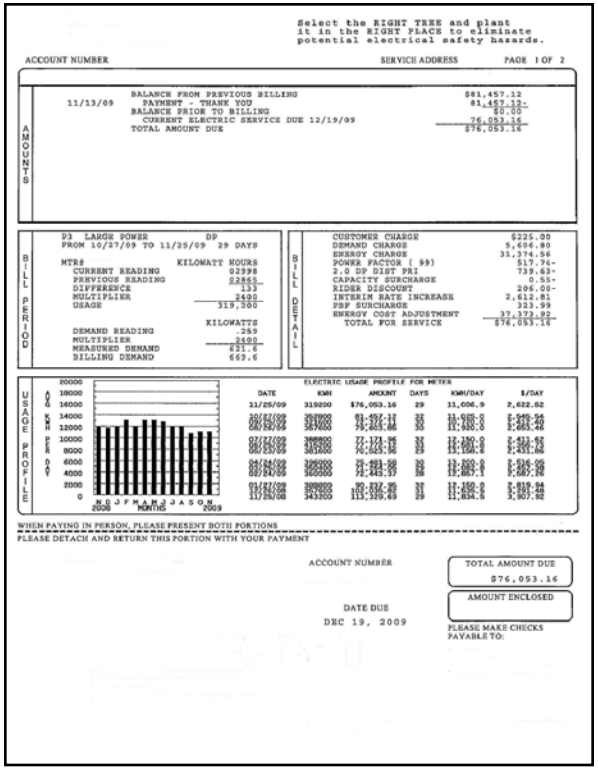
Audit Sequence – Pre Audit Info Gathering

- Site plan
- All utility bills
- Utility schedules
- Process flow diagram
- Electric diagrams
- Detailed equipment list with installation dates
- Pre site visit analysis



Audit Sequence – Utility Bill Analysis

- Local rate schedules
- Reconcile energy use
- Create baseline
- Develop energy accounting assumptions
- Minimum 2 yrs of analysis
- Determine demand sensitive operations



Select the RIGHT TREE and plant
it in the RIGHT PLACE to eliminate
potential electrical safety hazards.

ACCOUNT NUMBER | SERVICE ADDRESS | PAGE 1 OF 2

AMOUNTS

	BALANCE FROM PREVIOUS BILLING	$81,457.12
11/13/09	PAYMENT - THANK YOU	81,457.12-
	BALANCE PRIOR TO BILLING	$0.00
	CURRENT ELECTRIC SERVICE DUE 12/19/09	76,053.16
	TOTAL AMOUNT DUE	$76,053.16

BILL PERIOD

P3 LARGE POWER DP
FROM 10/27/09 TO 11/25/09 29 DAYS

MTR#	KILOWATT HOURS
CURRENT READING	02998
PREVIOUS READING	02865
DIFFERENCE	133
MULTIPLIER	2400
USAGE	319,200
	KILOWATTS
DEMAND READING	.259
MULTIPLIER	2400
MEASURED DEMAND	621.6
BILLING DEMAND	669.6

BILL DETAIL

CUSTOMER CHARGE	$225.00
DEMAND CHARGE	5,606.80
ENERGY CHARGE	31,374.56
POWER FACTOR (99)	517.74-
2.0 DP DIST PRI	739.63-
CAPACITY SURCHARGE	0.55-
RIDER DISCOUNT	206.00-
INTERIM RATE INCREASE	2,612.81
PBP SURCHARGE	323.99
ENERGY COST ADJUSTMENT	37,373.92
TOTAL FOR SERVICE	$76,053.16

USAGE PROFILE

ELECTRIC USAGE PROFILE FOR METER

DATE	KWH	AMOUNT	DAYS	KWH/DAY	$/DAY
11/25/09	319200	$76,053.16	29	11,006.9	2,622.52
10/27/09	[illegible]	[illegible]	33	[illegible]	[illegible]
09/22/09	[illegible]	[illegible]	35	[illegible]	[illegible]
07/27/09	[illegible]	[illegible]	31	[illegible]	[illegible]
06/25/09	[illegible]	[illegible]	29	[illegible]	[illegible]
05/26/09	[illegible]	[illegible]	30	[illegible]	[illegible]
04/26/09	[illegible]	[illegible]	31	[illegible]	[illegible]
03/26/09	[illegible]	[illegible]	34	[illegible]	[illegible]
01/27/09	[illegible]	[illegible]	31	[illegible]	[illegible]
12/26/08	[illegible]	[illegible]	34	[illegible]	[illegible]

WHEN PAYING IN PERSON, PLEASE PRESENT BOTH PORTIONS
PLEASE DETACH AND RETURN THIS PORTION WITH YOUR PAYMENT

ACCOUNT NUMBER

TOTAL AMOUNT DUE $76,053.16

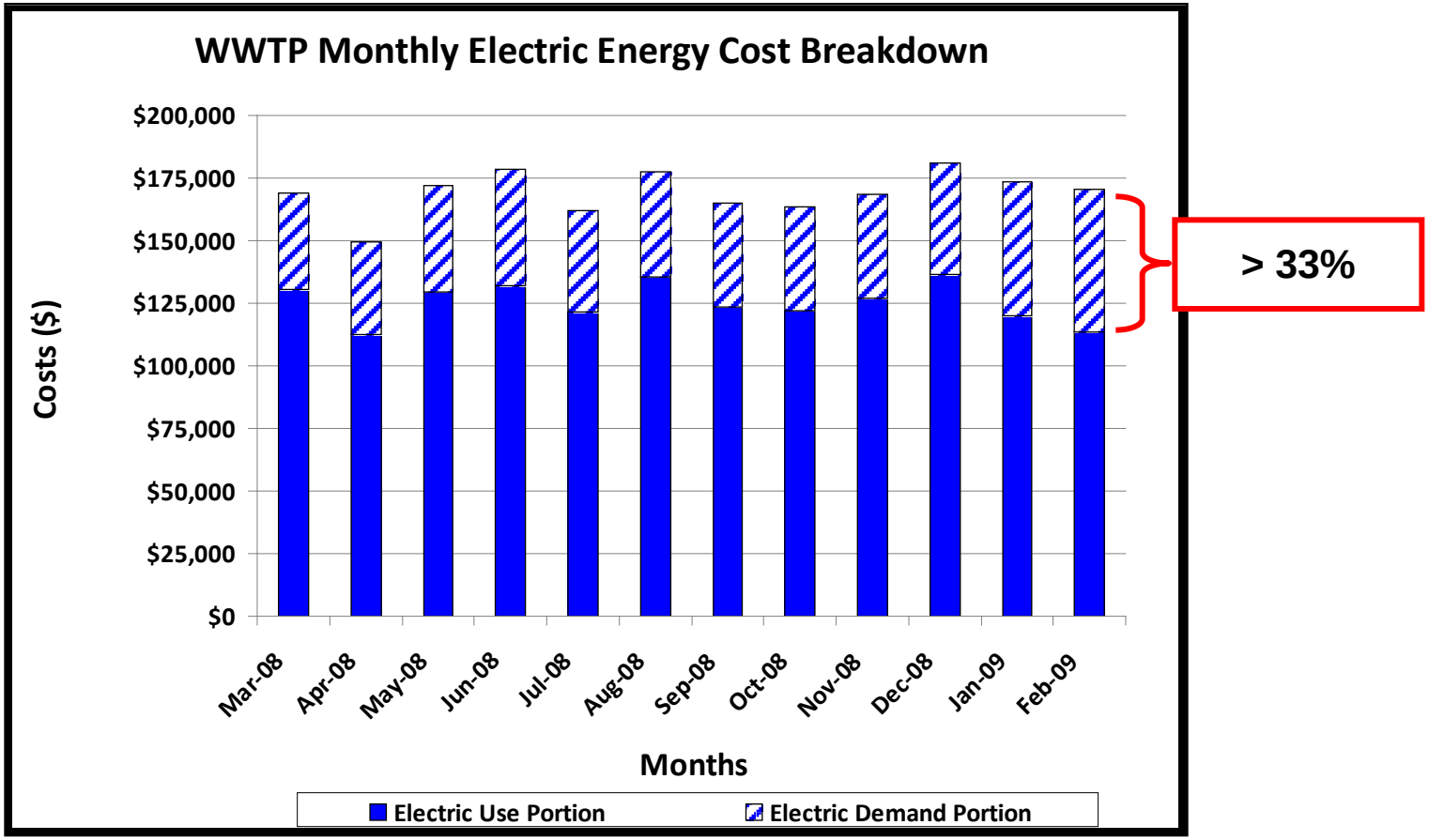
AMOUNT ENCLOSED

DATE DUE
DEC 19, 2009

PLEASE MAKE CHECKS PAYABLE TO:

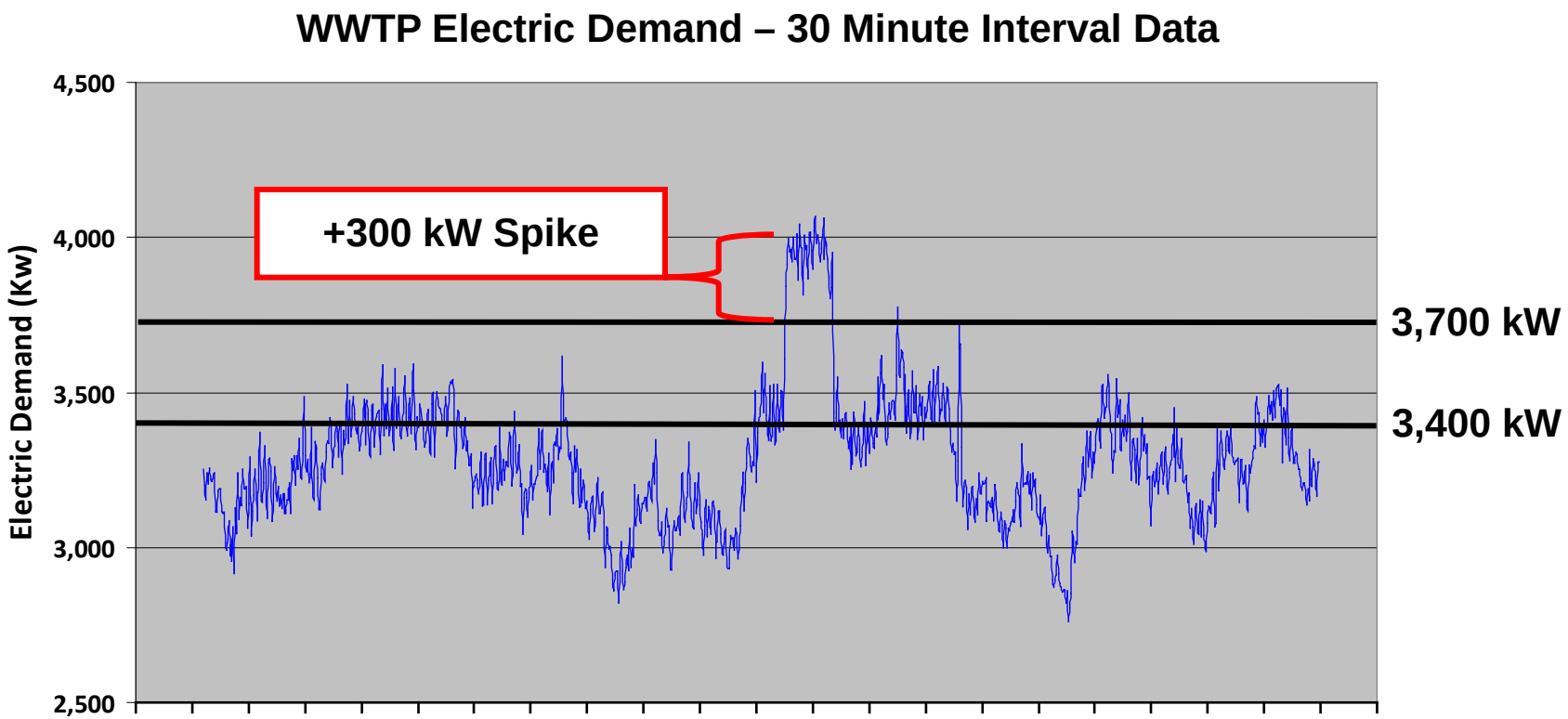
Audit Sequence – Electric Demand Sensitivity

- Demand can be 15-40% of your elec. costs



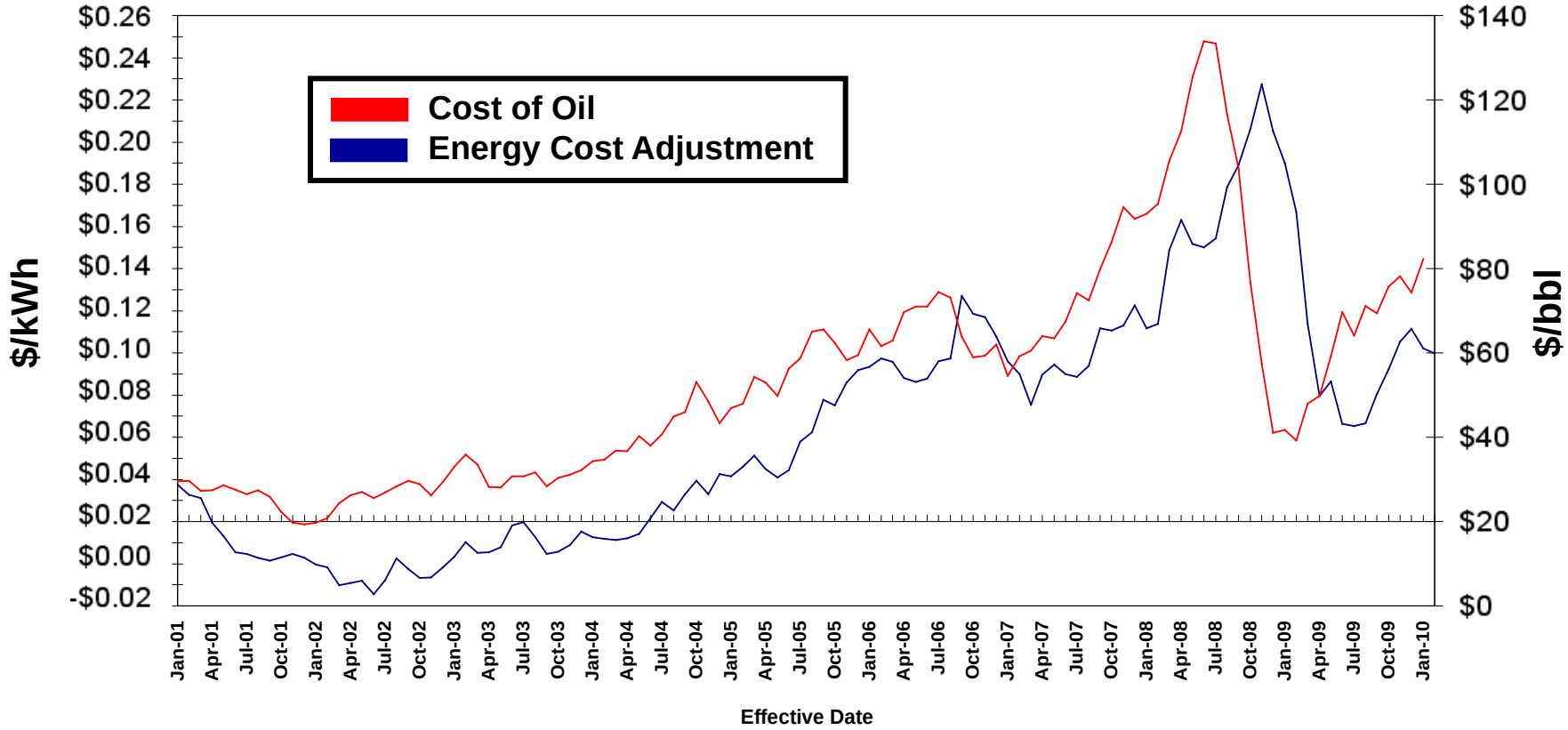
Audit Sequence – Demand Sensitivity Cont…

- Determining your demand spikes can save $
- 300kW over typical peak demand = $50k/yr



Audit Sequence – Energy Cost Adjustment

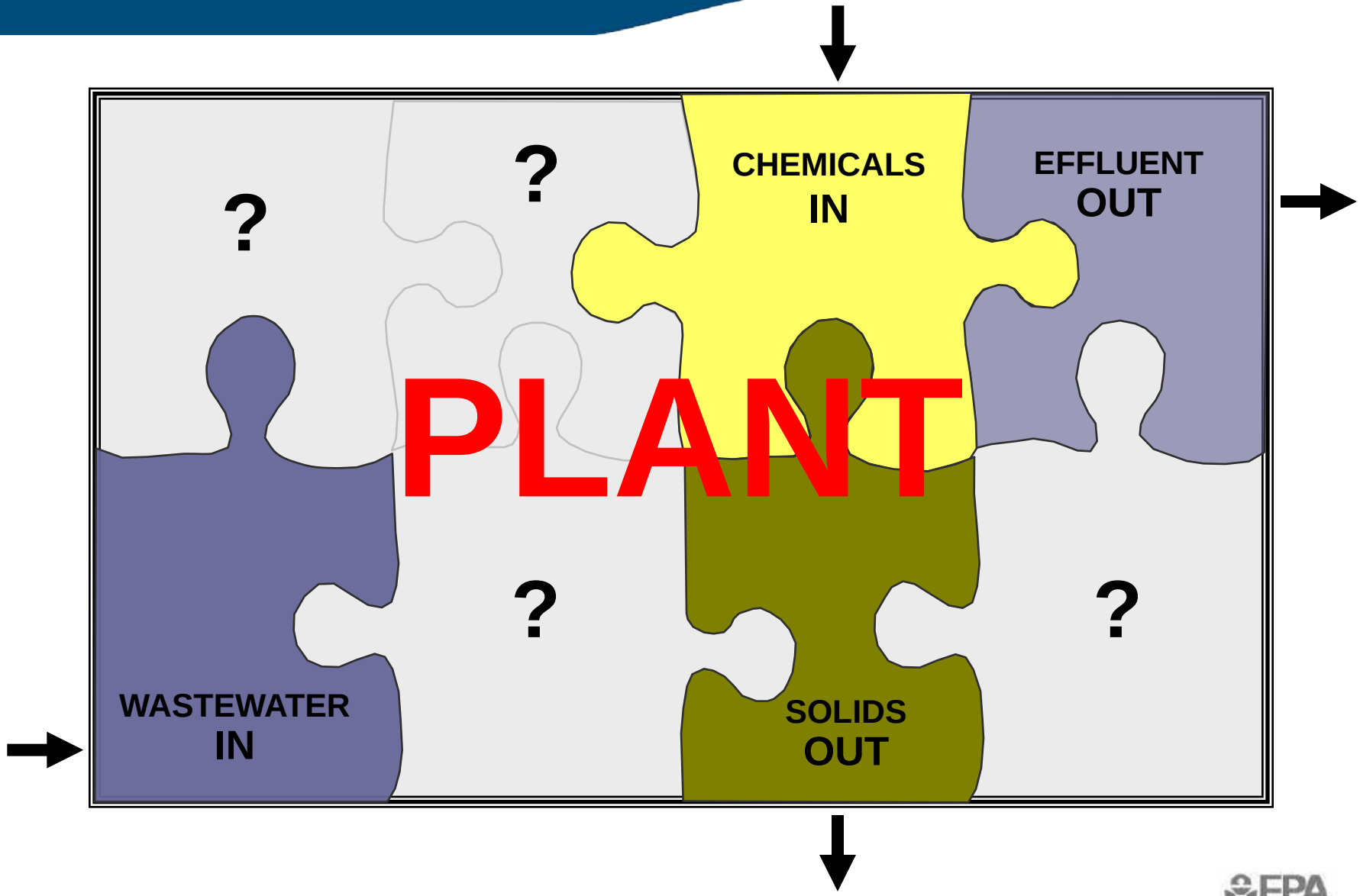
- This factor is somewhat unique to Hawaii
- This factor is added to energy use (kWh)



Audit Sequence – Baseline & Benchmark

- Goal development – where are you?
- Your personal “Benchmark”
- Framework for strategic planning
- Benchmark analysis allows industry comparison on a “macro level”
- Factor in local considerations
- Benchmark comparison options include: self, regional, national, etc…

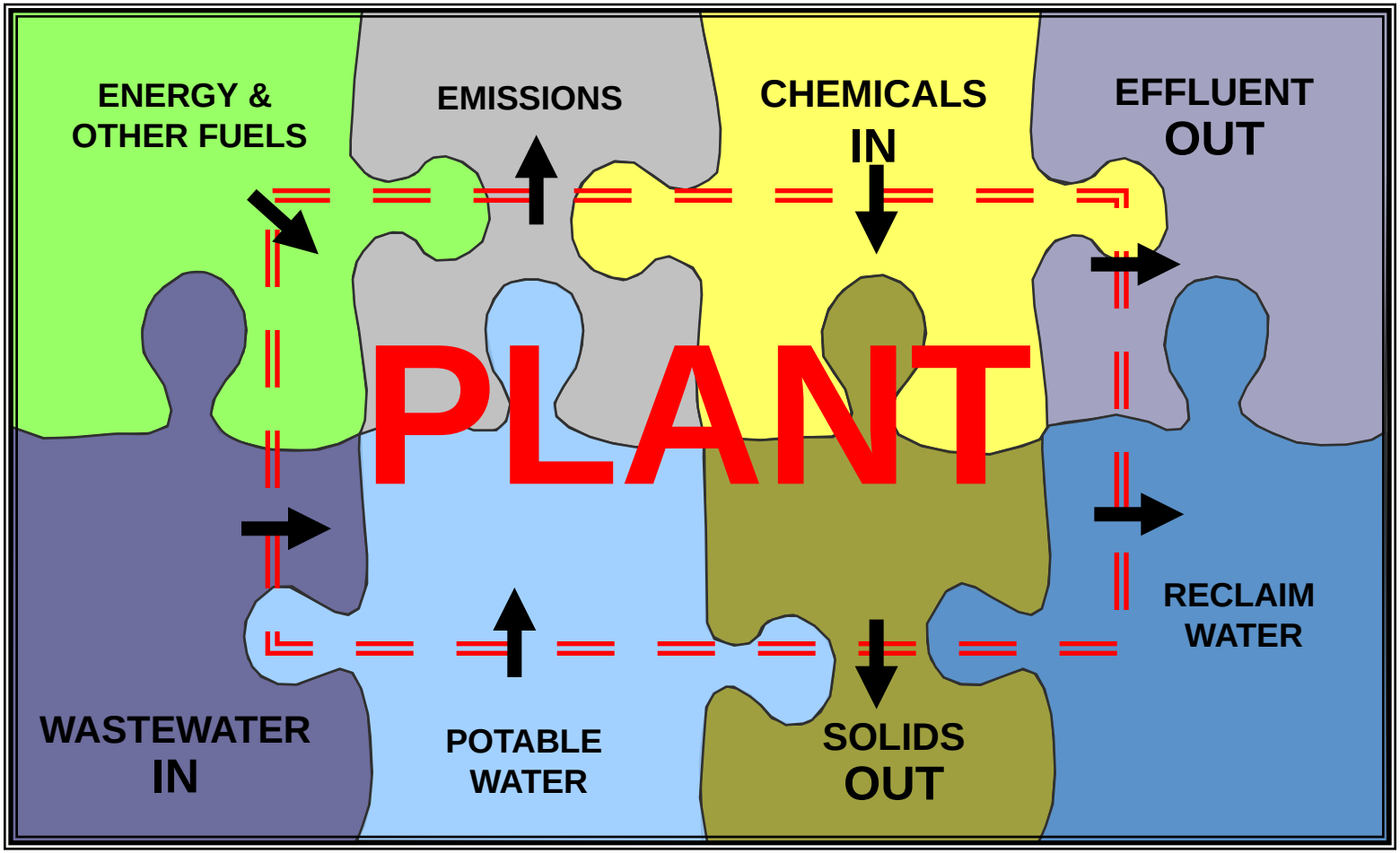
Audit Sequence – What Energy Balance?



Audit Sequence – Energy Balance Part 1

- Draw boundary (BOX) around plant
- Determine all materials and energy entering and exiting the BOX
  - Influent flow into and through plant
  - Energy and fuel into plant
  - Potable water into plant
  - Effluent flow out of plant
  - Solids out of plant
  - Self-generated energy out of plant

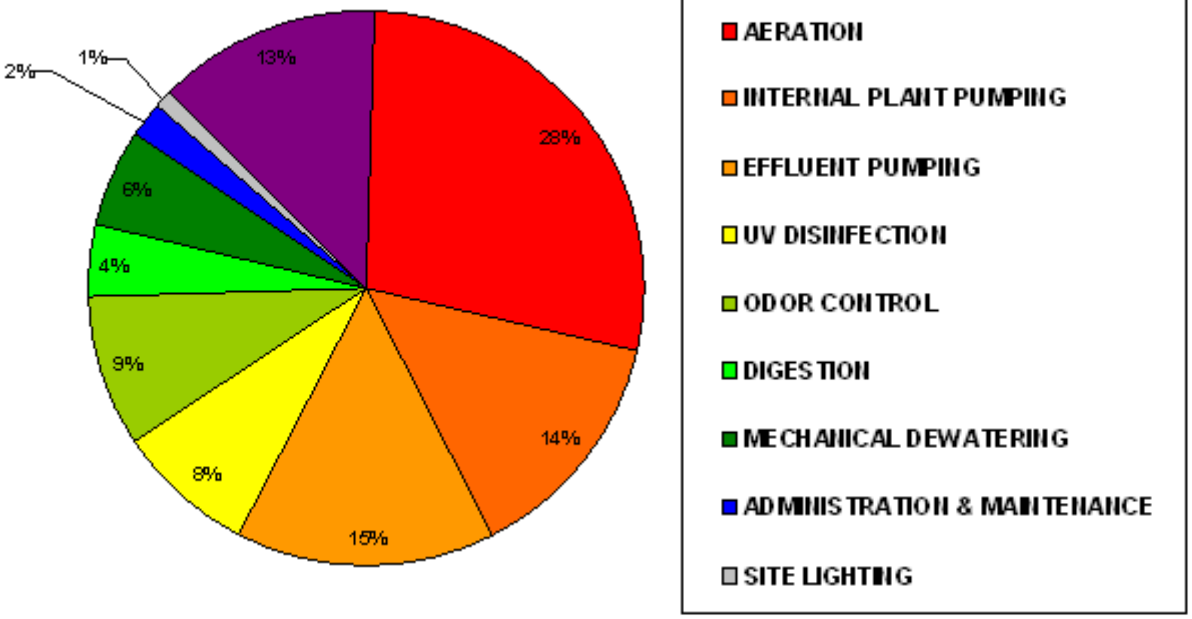
Audit Sequence – Your Energy Balance!



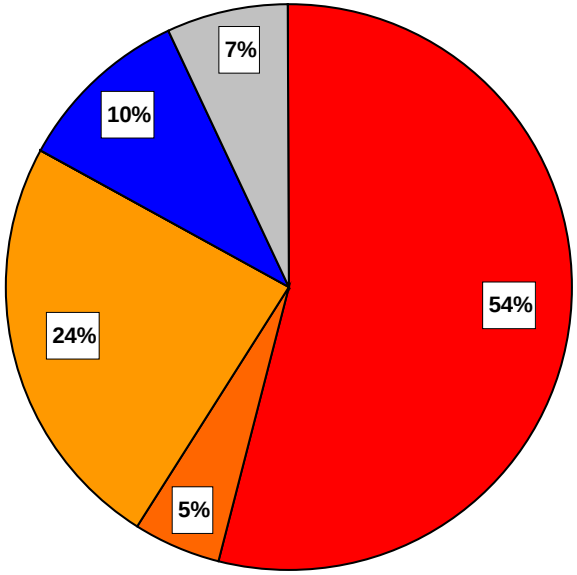
Audit Sequence – Energy Balance Part 2

- Develop baseline metrics (e.g.MMBTU$_{eq}$ per MG)
- Analyze energy use for each process type

PLANT #1



PLANT #2



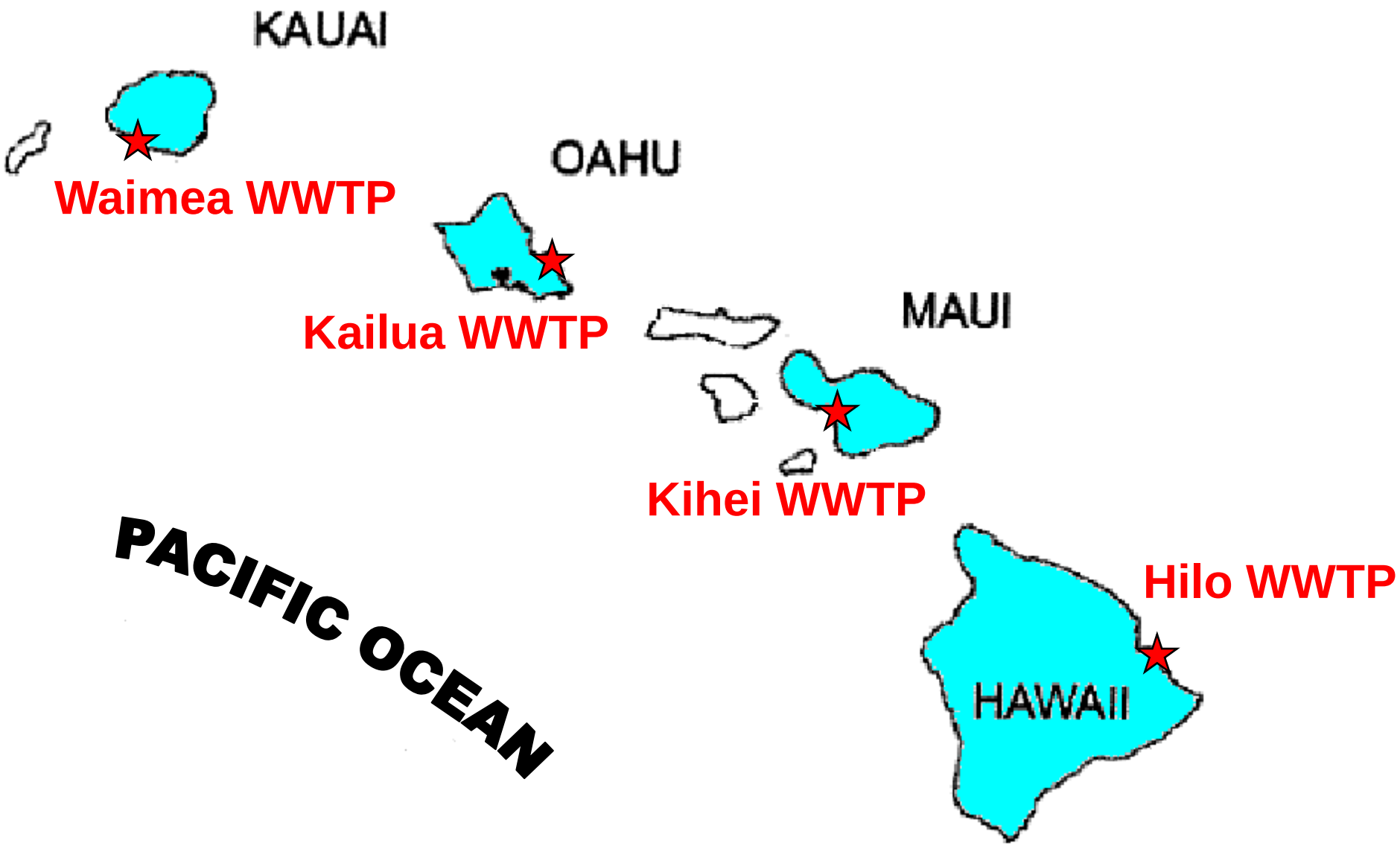
Energy Analysis – ECO Development

- What's an ECO?
- ECO = Energy Conservation Opportunity
- Ask the "Investigative" questions
  - "Why are blowers operating 24/7?"
  - "Why are UV and chlorine disinfection required prior to discharge?"
  - "How efficient is a constant pressure pumping system with variable demands?"
  - "How often does sludge dewatering occur?"

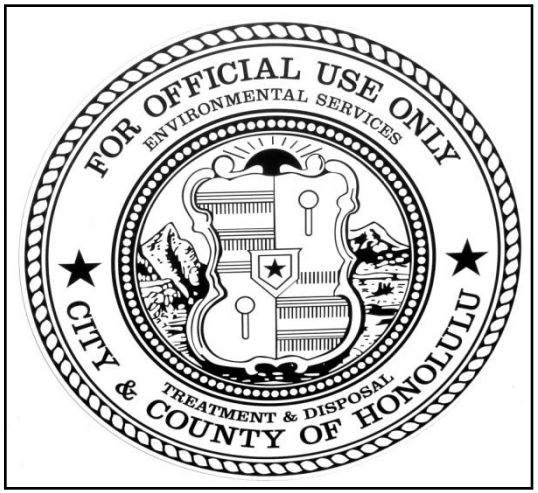
Energy Analysis – Example ECOs

- High efficiency motors
- Variable operation motors and drives
- Process optimization
- Process replacement
- Schedule modifications
- Water reuse

The Hawaii Story



Four Plants…. Four Stories

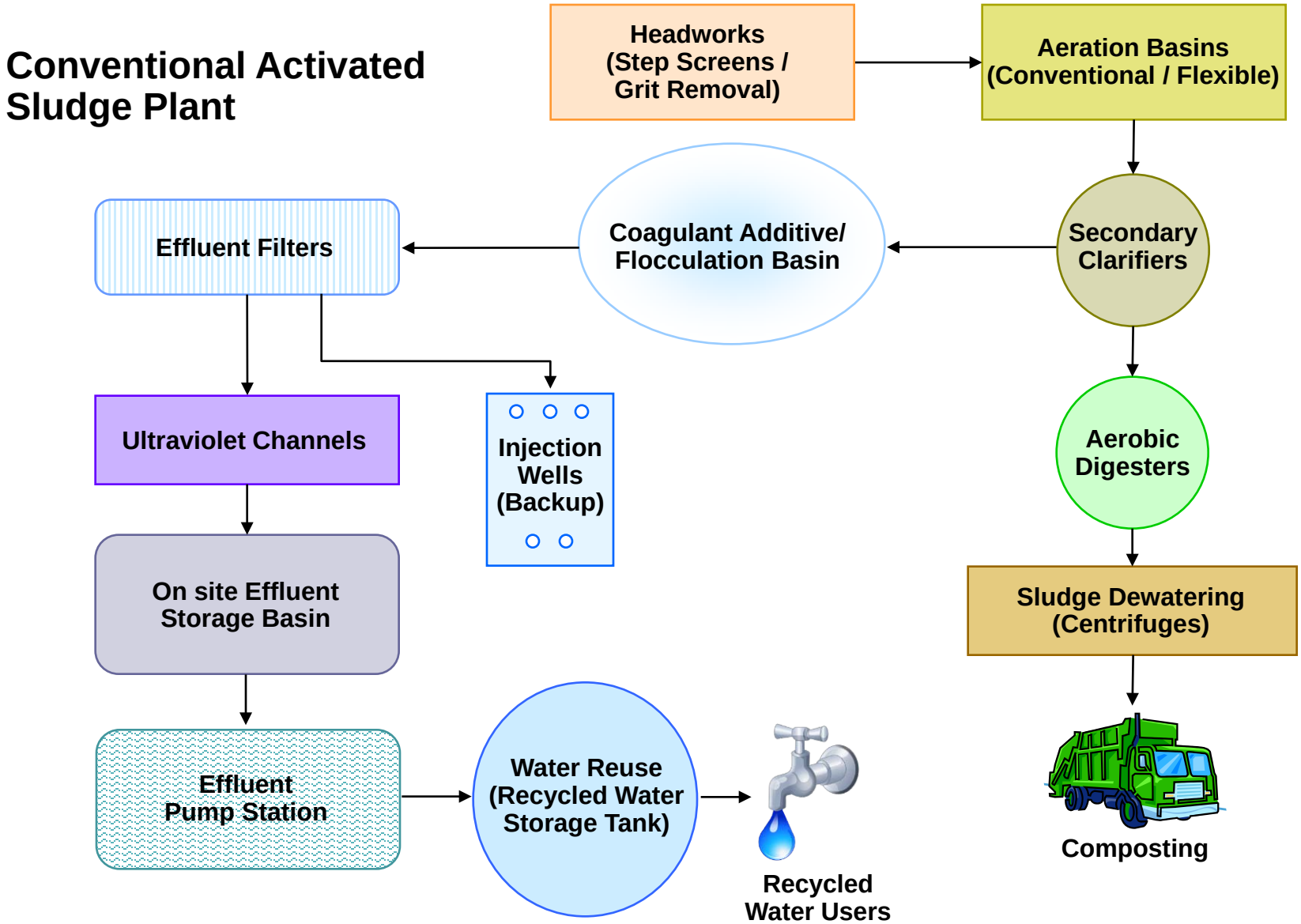


Hawaii - *Four Plants, Four Stories*

- Kailua WWTP, Oahu
  - 13 MGD / Fixed film
  - Influent & effluent pumping
  - Comprehensive odor control
  - UV disinfection
  - Anaerobic digestion
- Waimea, Kauai
  - 0.25 MGD / Aeration basins
  - Influent & effluent pumping
  - New treatment plant coming soon
  - Effluent reuse
- Kihei, Maui
  - 3.5 MGD / Aeration Basins
  - Reclaim water & effluent pumping
  - UV disinfection
  - Effluent reuse
- Hilo, Hawaii
  - 2.5 MGD/ Fixed film
  - NO influent & effluent pumping
  - Anaerobic digestion

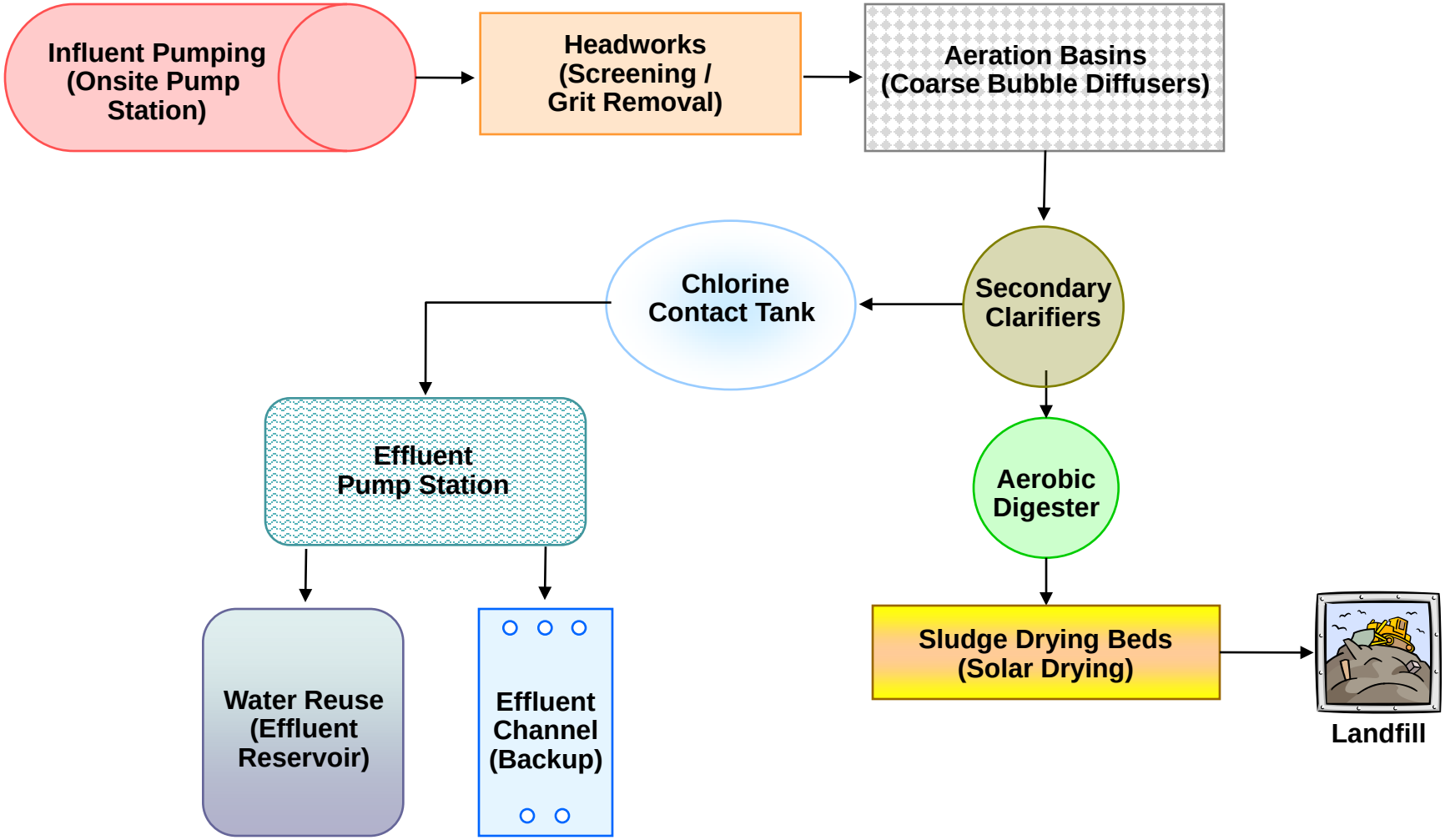
EPA

WWTP Flow Diagram - Kihei

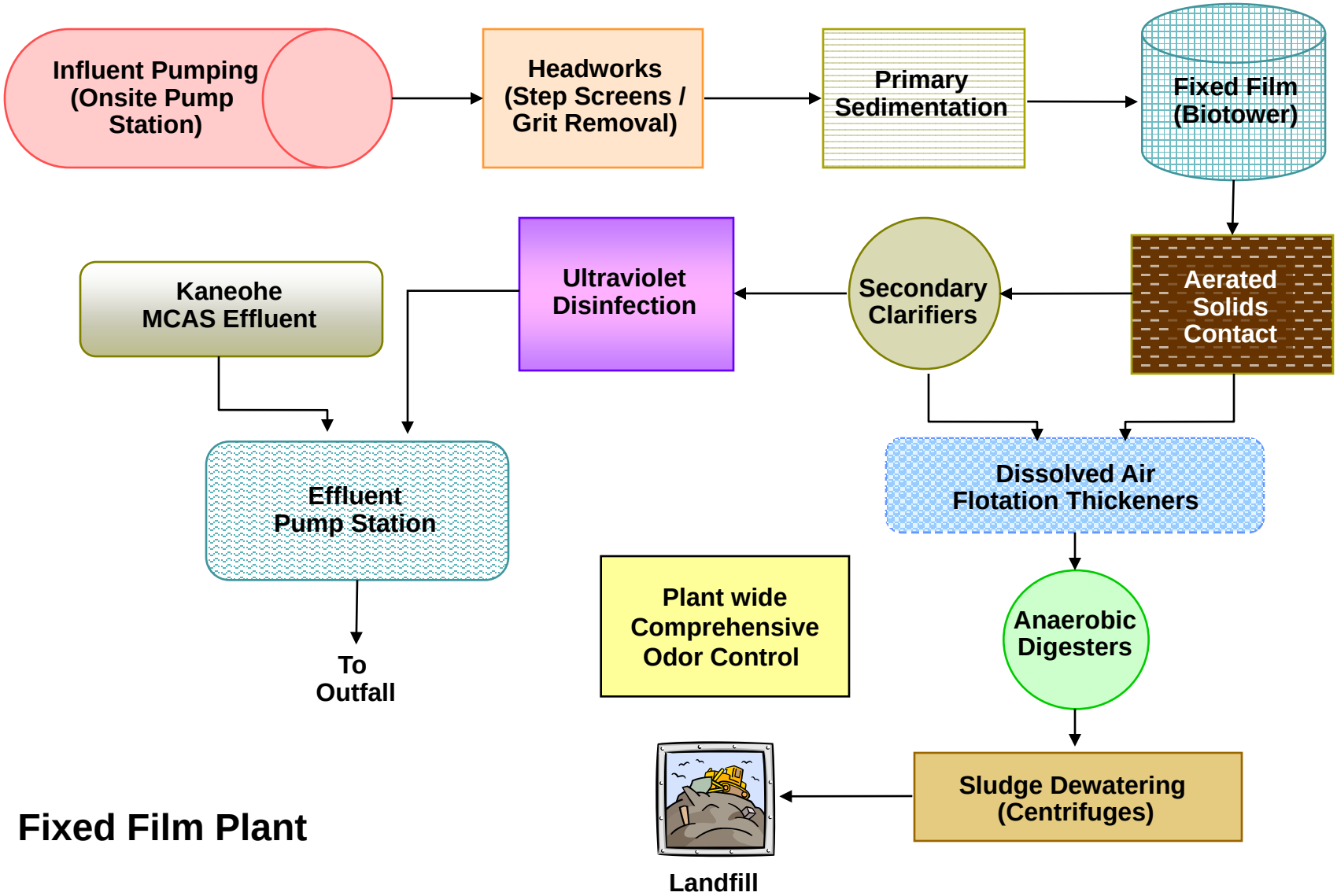


WWTP Flow Diagram - Waimea

Conventional Activated Sludge Plant

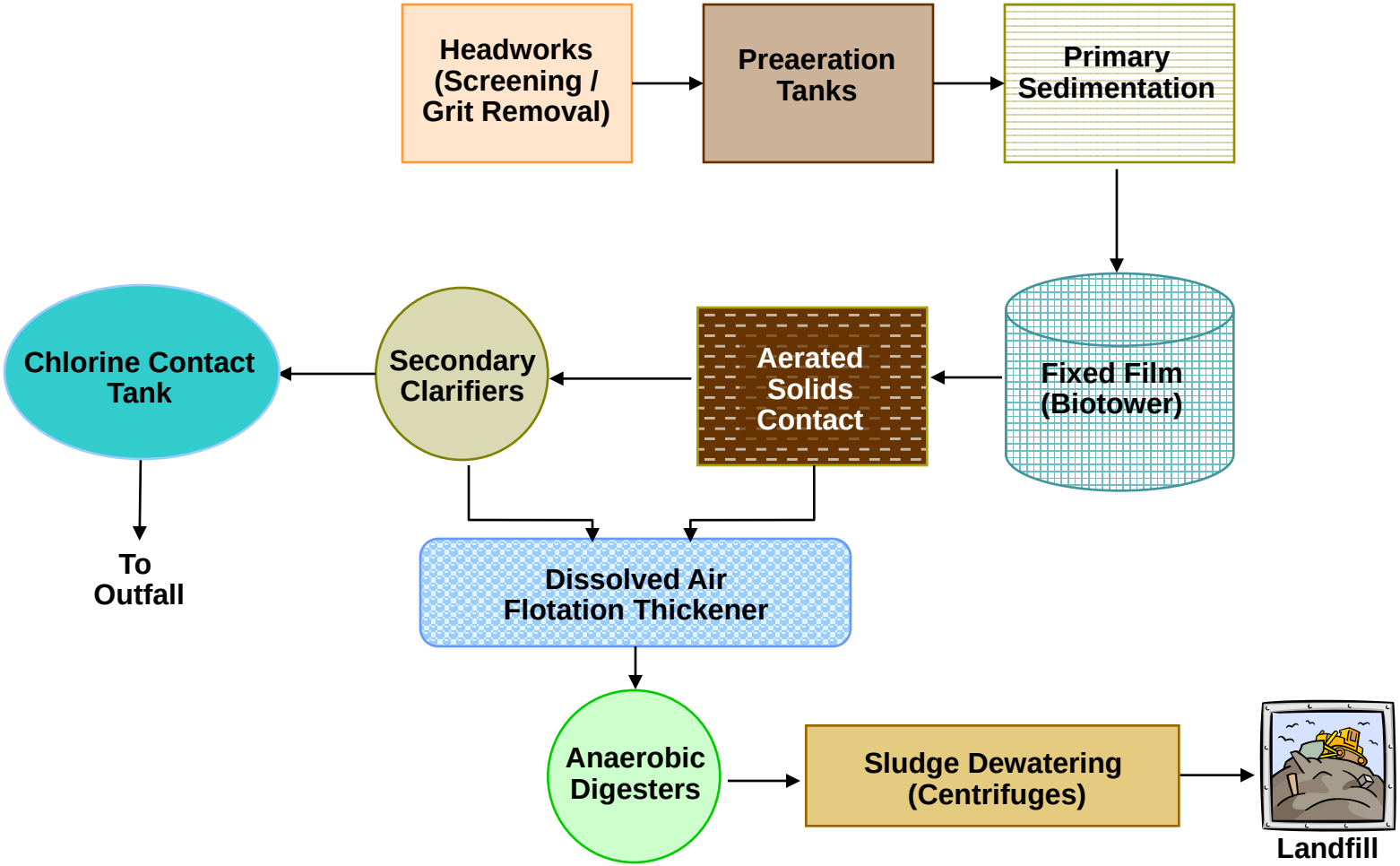


WWTP Flow Diagram - Kailua



Fixed Film Plant

WWTP Flow Diagram - Hilo

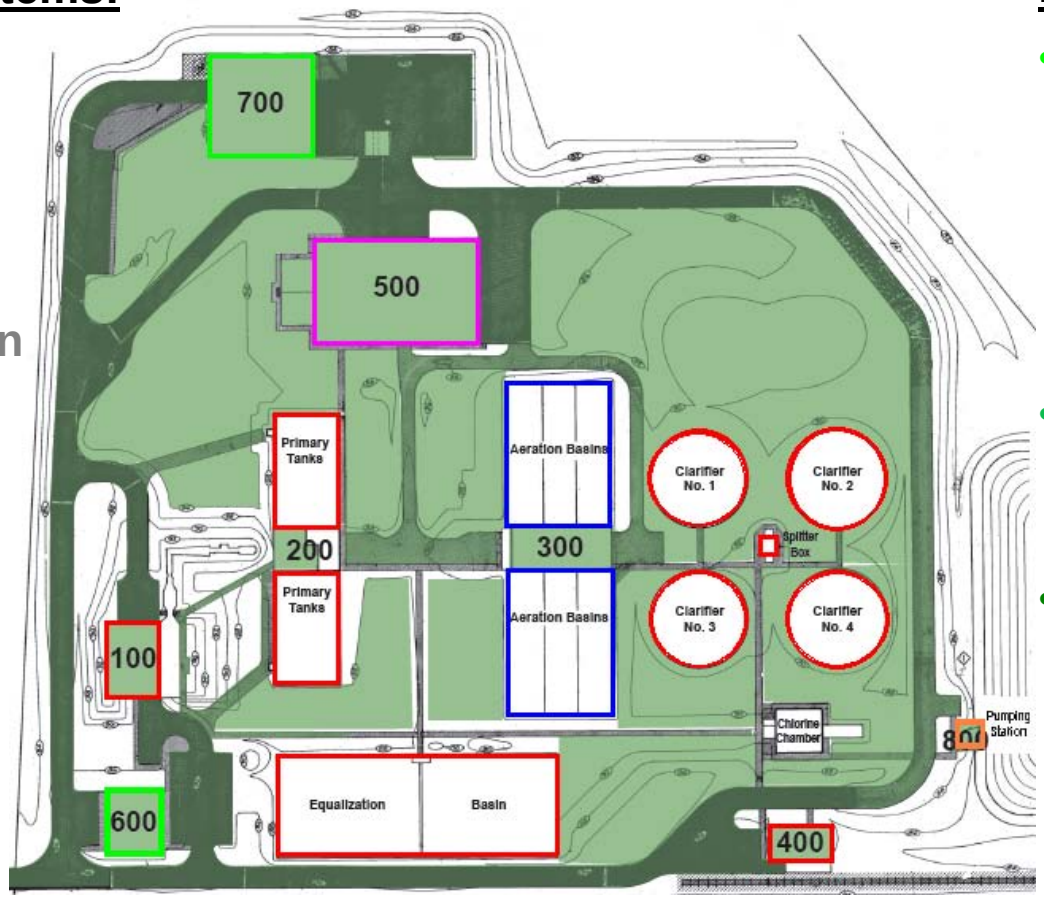


Fixed Film Plant

WWTP – Energy Audit Evaluation Areas

Process Systems:

- Hydraulic Capacity
- Aeration
- Pumping
- Disinfection
- Biosolids



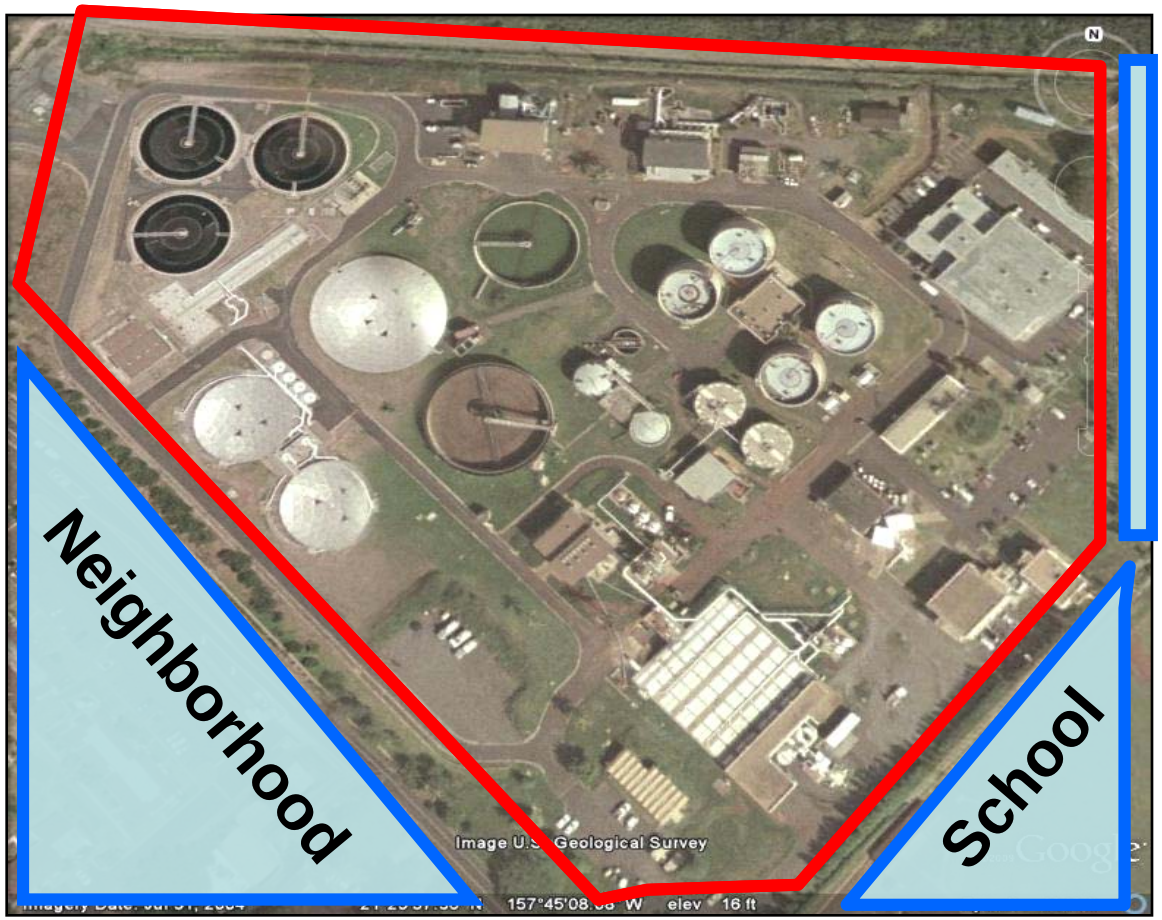
Non-Process:

- Buildings
  - Roofs
  - Walls
  - Lighting
  - HVAC
  - Space Utilization
- Property
  - Landscape
  - Site Design
- Vehicle Options

Both:

- Maintenance
- Reliability
- Security
- Automation
- Behavioral
- Site Utilities
- Renewable Energy
- Procurement

WWTP Virtual Tour 1 of 10 – Site Layout



Kailua WWTP Site Layout

- Multiple buildings
- Multiple process systems
- Different operating schedules
- Property limitations
- Odor control issues

Virtual Tour 2 of 10 – Influent Pumping

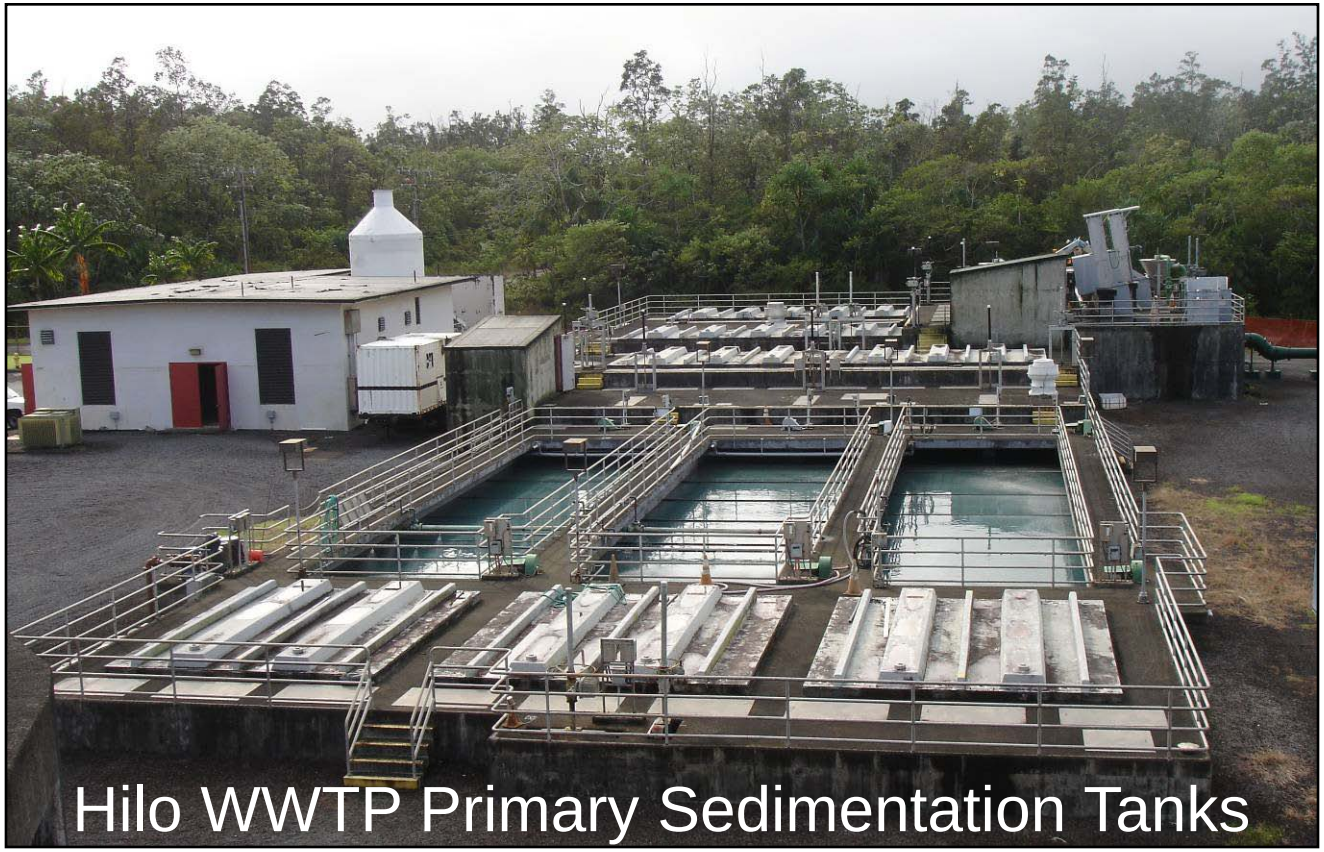
- Gravity fed or pumped flow
- Flow control

Virtual Tour 3 of 10 – Pre Treatment

- Screening and solids removal equipment
- Odor control

Virtual Tour 4 of 10 – Primary Treatment

- Primary sedimentation tanks
- Wastewater and sludge pumping



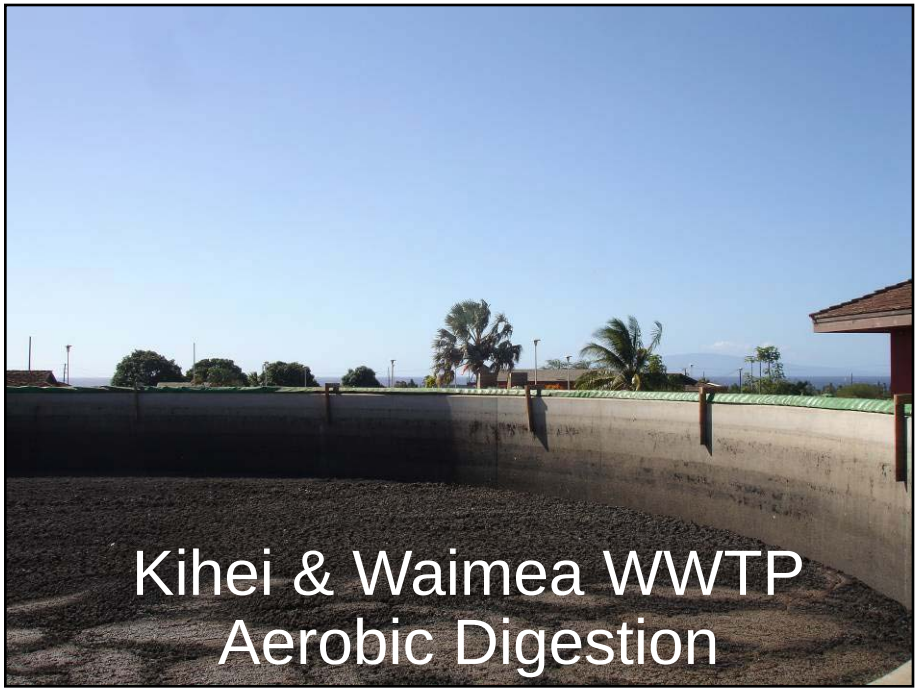
Virtual Tour 5 of 10 – Secondary Treatment

- Fixed film or conventional activate sludge?

Hilo WWTP
Biotowers & Pumps

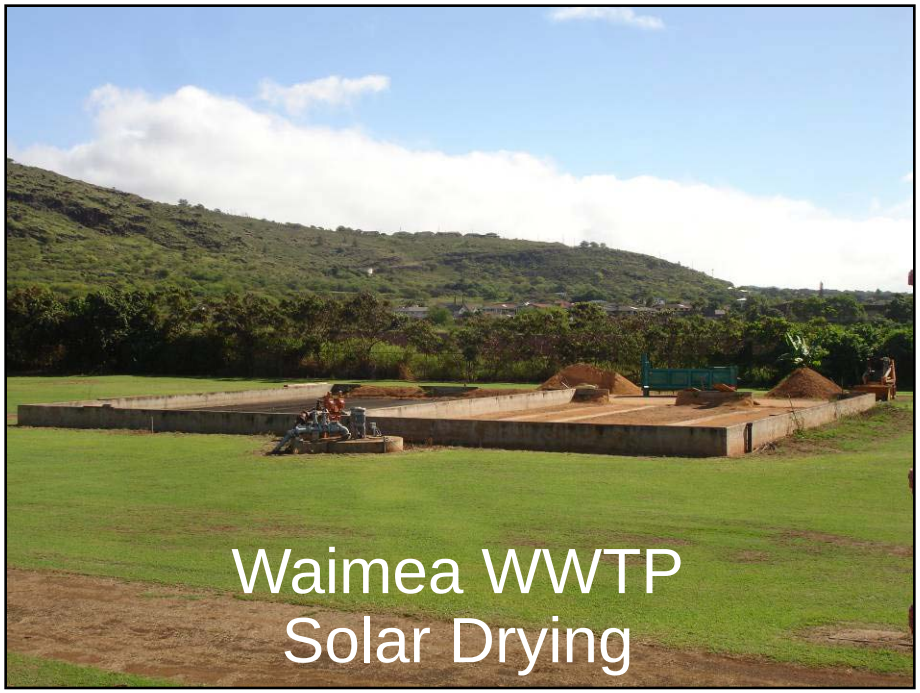
Virtual Tour 6 of 10 – Sludge Treatment

- Methods - digestion, composting and incineration
- Typically depends on amount of solids generated



Virtual Tour 7 of 10 – Solids Dewatering

- Required to make sludge suitable for disposal
- No process exists to eliminate need for biosolids disposal



Virtual Tour 8 of 10 – Disinfection

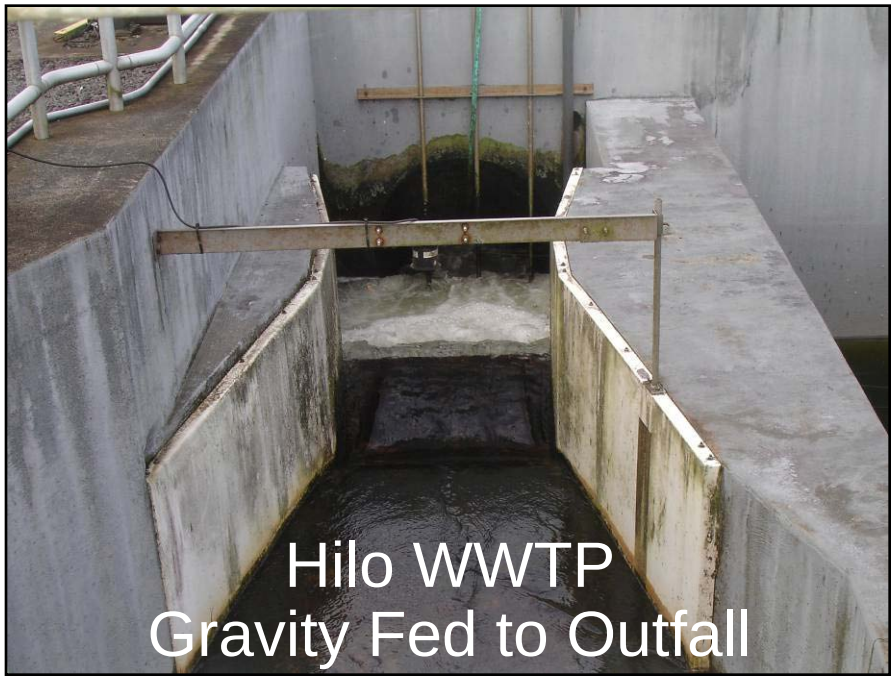
- Methods – ozone, chlorine and ultraviolet (UV) light

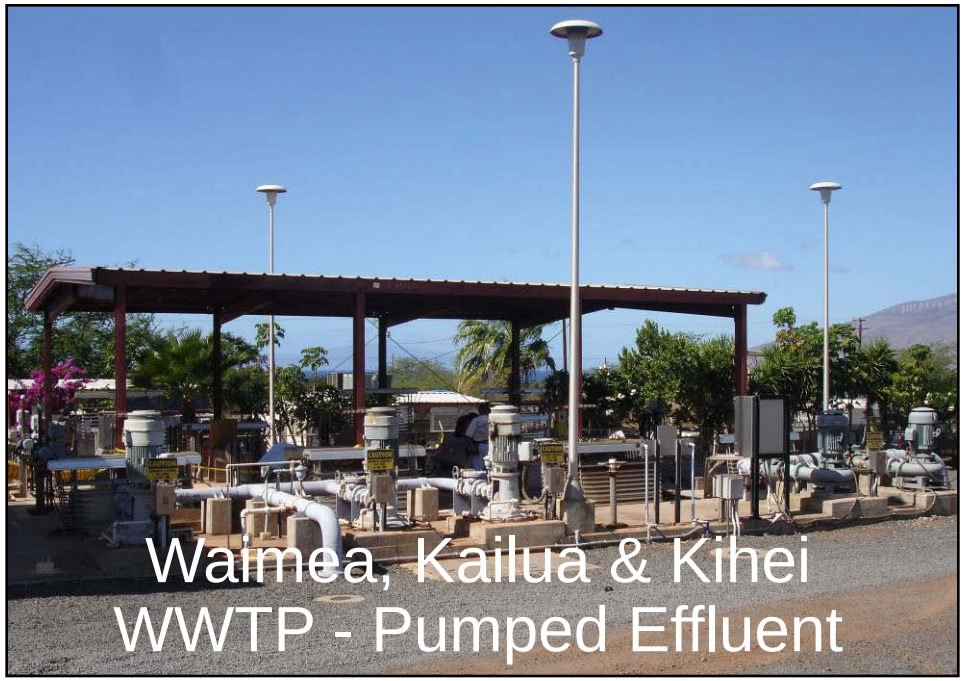
Hilo & Waimea WWTP
Chlorination

Kailua & Kihei WWTP
Ultraviolet Light

Virtual Tour 9 of 10 – Effluent Pumping

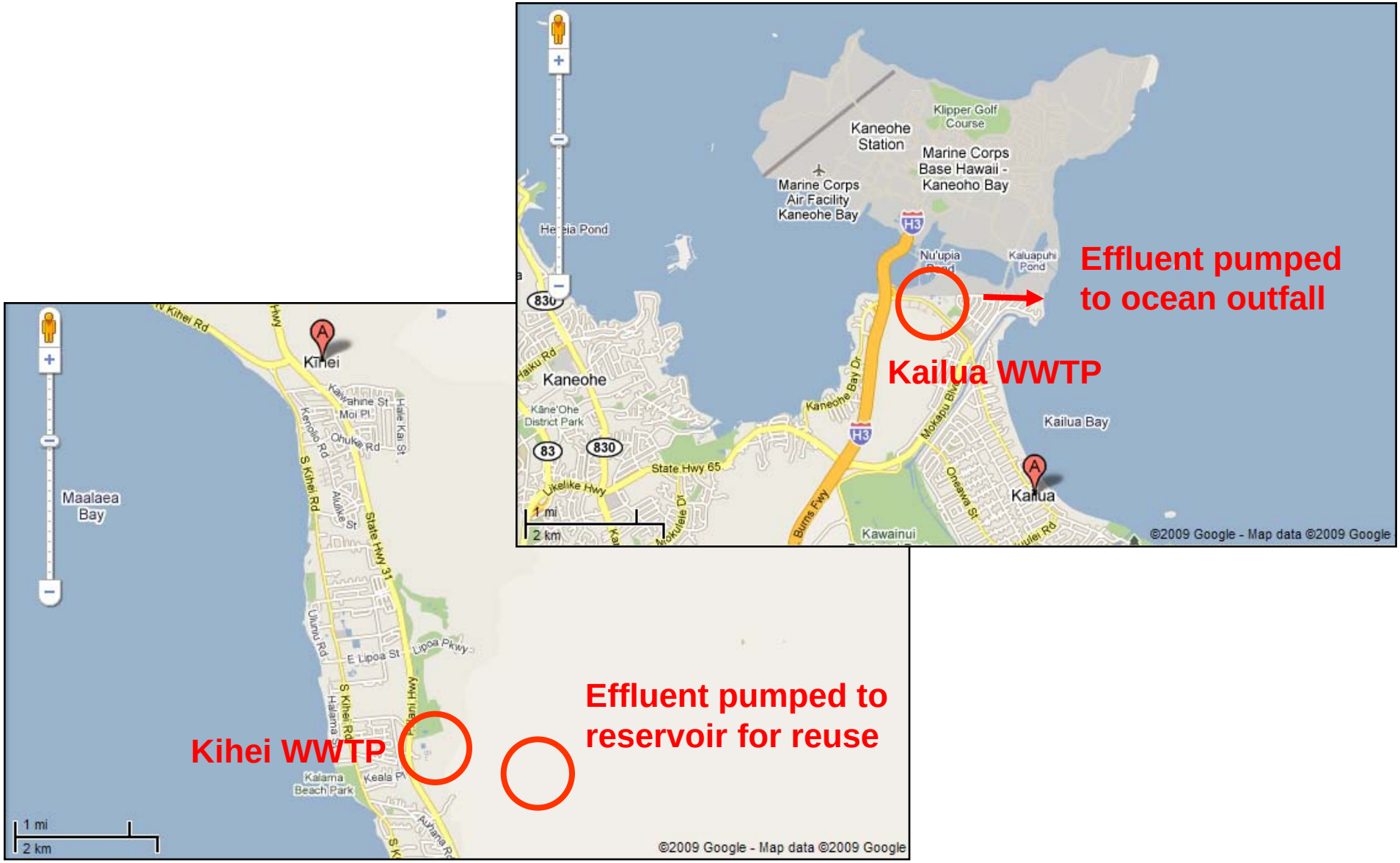
- Gravity fed or pumped flow
- Flow control
- Water reuse – 2 of 4 WWTP





Virtual Tour 9 of 10 – Effluent Pumping Cont…

Virtual Tour 9 of 10 – Effluent Pumping Cont…



Virtual Tour 10 of 10 – Auxiliary Systems

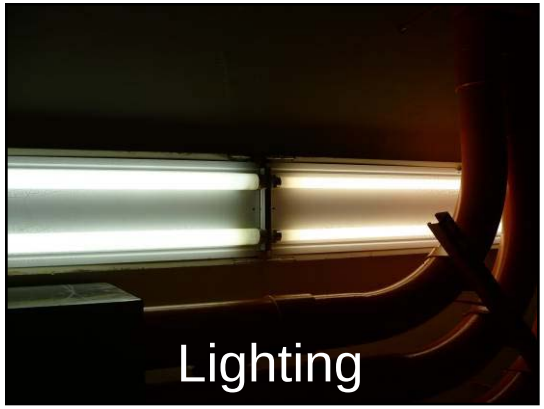
Compressed Air

Odor Control

City Water & Site Booster

Controls & Auto.

Aeration Blowers


Lighting

Four Stories - Four Unique Circumstances

Considerations associated with auditing infrastructure facilities:

- Every facility is unique with ever-changing and uncontrollable parameters
- Plants have specific process requirements
- Site specific permits, restrictions, regulations and rate structures
- Each plant is located in a unique setting providing potential opportunities and specific issues to overcome

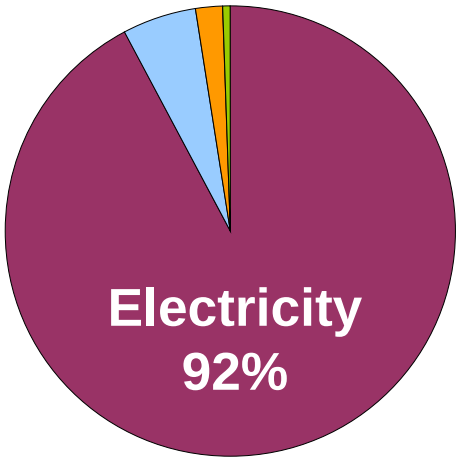
EPA

Comparing “Treatment Plant Unique DNA”

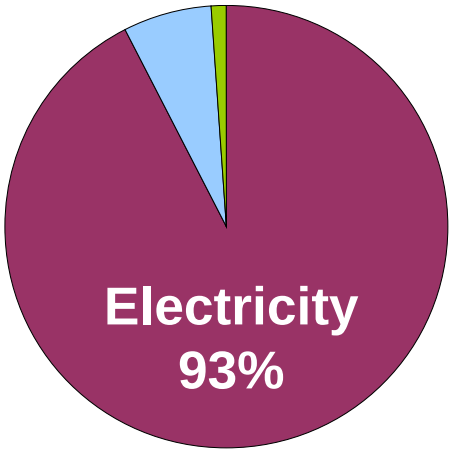
PROCESS	HILO	KAILUA	KIHEI	WAIMEA
Influent Pumping		■		■
Screening/Grit Removal	■	■	■	■
Primary Sedimentation	■	■		
Fixed Film (Biotower)	■	■		
Aeration Basins			■	■
Secondary	■	■	■	■
Solids Contact	■	■		
Advanced Water Treatment			■	
Chlorine Disinfection	■			■
Ultraviolet		■	■	
Effluent Pumping		■	■	■
Common Outfall Pumping		■		
Comprehensive Odor Control		■		
Thickening	■	■		
Aerobic Digestion			■	■
Anaerobic Digestion	■	■		
Digester Gas Utilization-Heating	■	■		
Digester Gas-Cogeneration				
Dewatering-Centrifuge	■	■	■	
Dewatering-Solar Drying				■
Landfill	■	■		■
Composting			■	
Water Reuse			■	■
FOG Program			■	

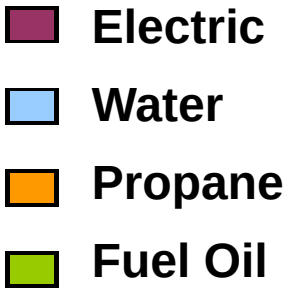
Resource Cost Breakdown

Hilo WWTP = $650,000/yr

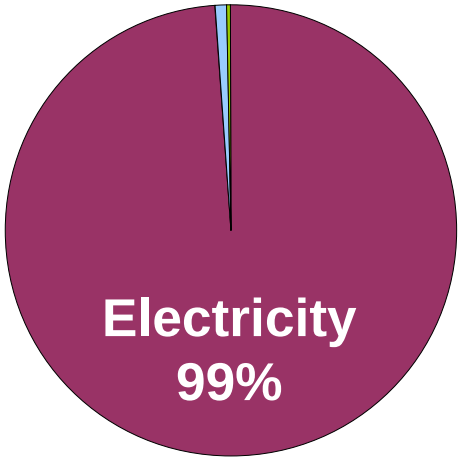


Kailua WWTP = $1,700,000/yr

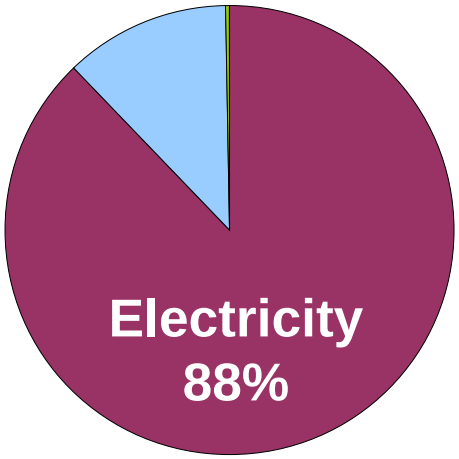




Kihei WWTP = $1,000,000/yr



Waimea WWTP = $100,000/yr



Hilo WWTP Electrical Energy Breakdown

Electrical Energy User / Equipment Description	Est. Electric Energy Use (kWh/yr)	Est. Electric Energy Cost ($/yr)	Est. Electric Energy Use/ Cost (%)
Biotower Pumps	663,000	$209,000	33%
Primary Aeration Blowers	431,000	$136,000	22%
No. 3 Water Pumps	226,000	$71,000	11%
Digester Sludge Mix Pumps	184,500	$58,000	9%
Secondary Aeration Blowers	74,500	$23,000	4%
Solids Processing Odor Ctrl Fan	76,000	$24,000	4%
No. 2 Water Pumps	51,000	$16,000	3%
Grit Pumps	65,500	$21,000	3%
Primary Odor Control Fans	41,500	$13,000	2%
Primary Sludge Pumps	48,500	$15,000	2%
Balance of Plant	37,000	$12,000	2%
Admin/Maint Building Load	37,000	$12,000	2%
Centrifuges	18,500	$6,000	1%
Lighting Load	17,500	$6,000	1%
DAF Thickened Sludge Pumps	4,700	$1,000	0.2%
Digester Sludge Transfer	3,800	$1,000	0.2%
Est. Annual Electric Use	**1,980,000**	**$624,000**	**100%**

EPA

Kailua WWTP Electrical Energy Breakdown

Electrical Energy User / Equipment Description	Est. Electric Energy Use (kWh/yr)	Est. Electric Energy Cost ($/yr)	Est. Electric Energy Use/ Cost (%)
Effluent Pumps	2,189,000	$442,910	28%
Biotower Pumps	1,314,000	$265,867	17%
Influent Pumps	1,139,000	$230,459	14%
Secondary Odor Ctrl Fan	657,000	$132,934	8%
Secondary Aeration Blowers	526,000	$106,428	7%
DAF Sludge Pressurization Pumps	526,000	$106,428	7%
Primary Odor Ctrl Fan	438,000	$88,622	6%
Digester Sludge Pumps	350,000	$70,817	4%
Return Activated Sludge Pumps	228,000	$46,132	3%
Admin/Maint Building Load	174,000	$35,206	2%
Centrifuges	96,000	$19,424	1%
Solids Processing Odor Ctrl Fan	48,000	$9,712	1%
Digester Grinders	71,000	$14,366	1%
Centrifuge Sludge Pumps	38,000	$7,689	0.5%
Primary Sludge Pumps	39,000	$7,891	0.5%
Primary Effluent Pumps	22,000	$4,451	0.3%
Waste Activated Sludge Pumps	13,000	$2,630	0.2%
Sludge Thickener Pumps	15,000	$3,035	0.2%
DAF Pocket Pumps	15,000	$3,035	0.2%
Primary Grit Pumps	11,000	$2,226	0.1%
Primary Scum Pumps	11,000	$2,226	0.1%
Est. Annual Electric Use	**7,920,000**	**$1,602,489**	**100%**

EPA

Kiehi WWTP Electrical Energy Breakdown

Electrical Energy User / Equipment Description	Est. Electric Energy Use (kWh/yr)	Est. Electric Energy Cost ($/yr)	Est. Electric Energy Use/ Cost (%)
Primary Aeration Blowers	1,707,900	$368,231	39%
Effluent Pumps	867,000	$186,929	20%
Aerobic Digester Agitation Blowers	263,000	$56,704	6%
Sand Filter Sump Pumps	263,000	$56,704	6%
Plant Air Compressors	270,500	$58,321	6%
Admin/Maint Building Load	31,500	$6,792	1%
Clarifier #1 & #2 RAS Pumps	158,000	$34,065	4%
Influent Odor Control Fan	118,000	$25,441	3%
Filter Compressor Station	118,000	$25,441	3%
Reclaim Transfer Pumps	118,000	$25,441	3%
Balance of Plant	144,500	$31,155	3%
Centrifuges	79,000	$17,033	2%
UV Disinfection System	80,000	$17,248	2%
WAS Pumps #1 - #5	40,500	$8,732	1%
Anoxic Mixing Aeration Blowers	22,500	$4,851	1%
Plant Utility Water Pumps	54,000	$11,643	1%
Lighting Load	42,000	$9,055	1%
Digested Sludge Pumps	7,000	$1,509	0.2%
Est. Annual Electric Use	**4,384,400**	**$945,296**	**100%**

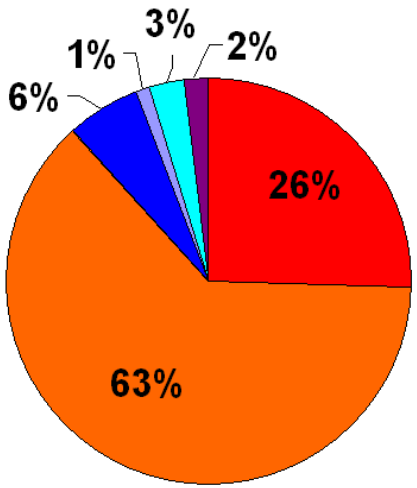
EPA

Waimea WWTP Electrical Energy Breakdown

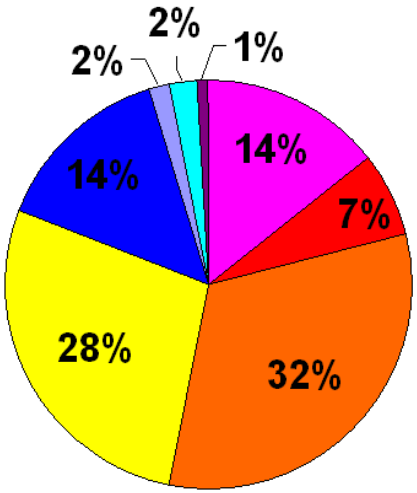
Electrical Energy User / Equipment Description	Est. Electric Energy Use (kWh/yr)	Est. Electric Energy Cost ($/yr)	Est. Electric Energy Use/ Cost (%)
Primary Aeration Blowers	202,100	$58,674	65%
Effluent Pumps	46,340	$13,454	15%
Influent Pumps	21,800	$6,329	7%
Balance of Plant	17,520	$5,086	6%
Admin/Maint Building Load	13,100	$3,803	4%
Lighting Load	11,300	$3,281	4%
Sludge Drying Bed Underdrain Pumps	430	$125	0.1%
Est. Annual Electric Use	**312,590**	**$90,752**	**100%**

WWTP Electrical Energy Breakdowns

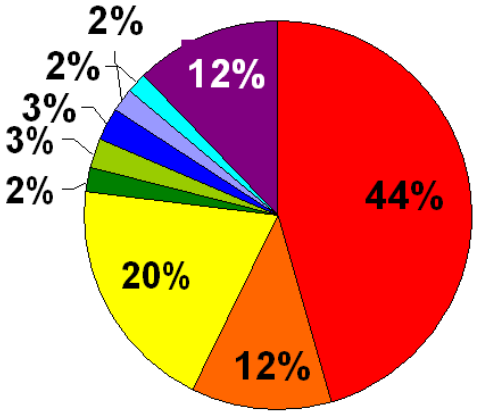
Hilo WWTP
1,980,000 kWh/yr



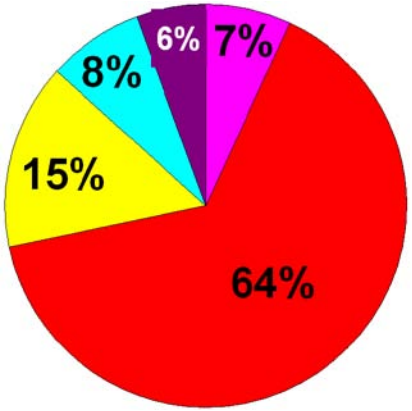
Kailua WWTP
7,920,000 kWh/yr



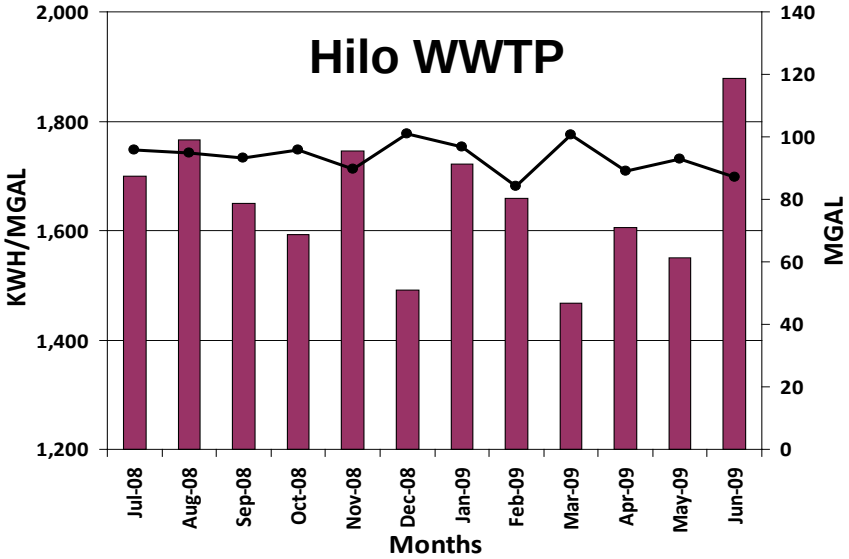
Kihei WWTP
4,384,000 kWh/yr

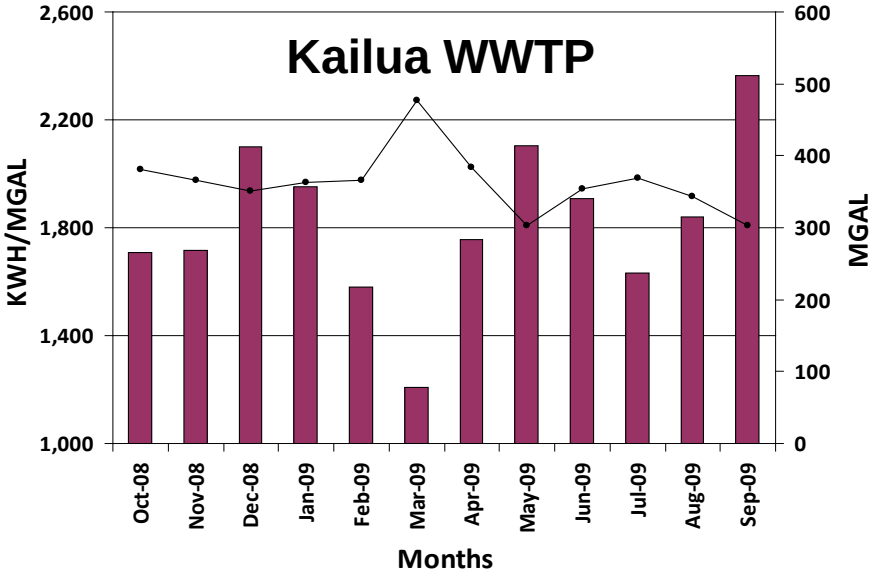


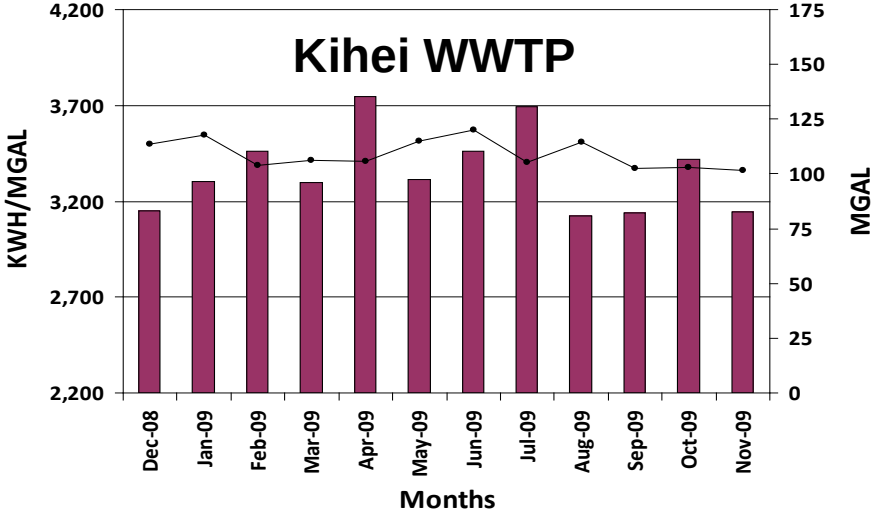
Waimea WWTP
313,000 kWh/yr

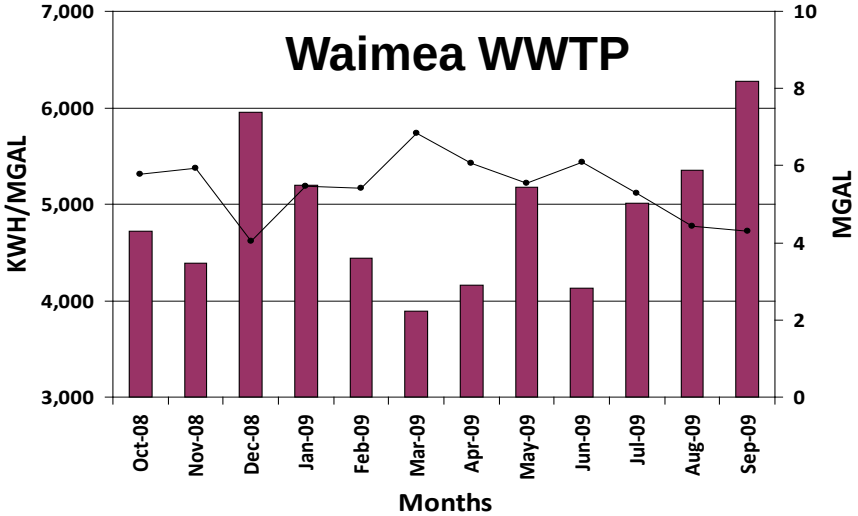


Current Plant Energy Baselines







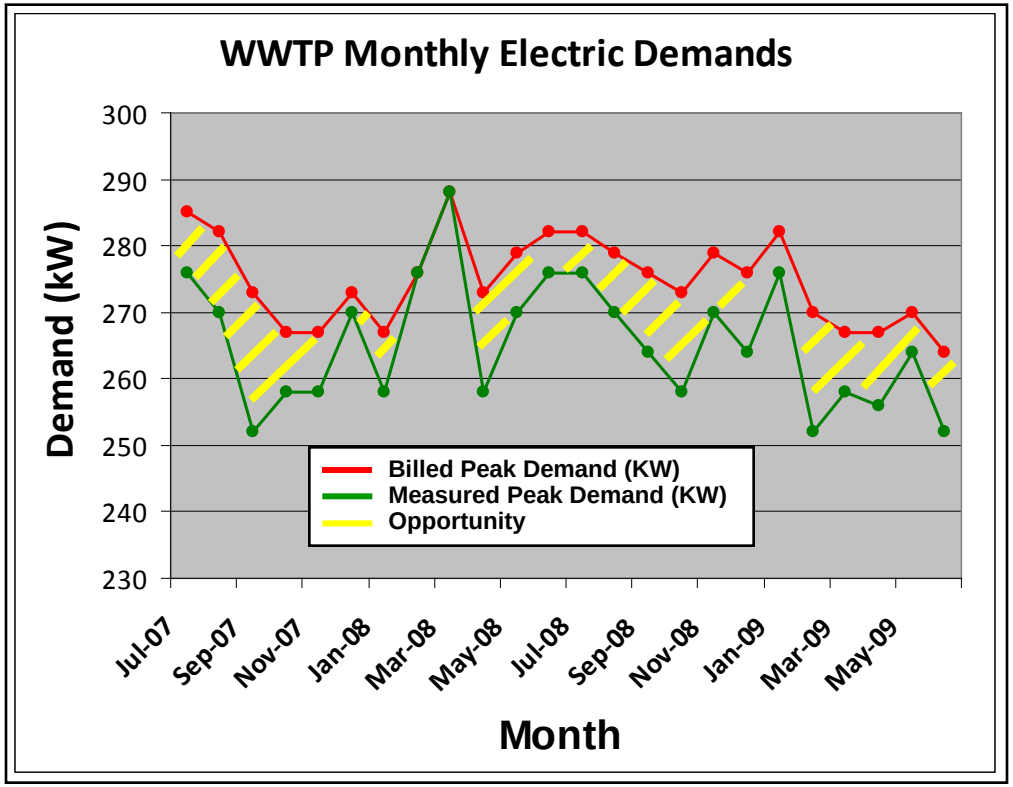


ECO #1 – Hilo Electric Demand Management

Hilo's Current Electrical Demands

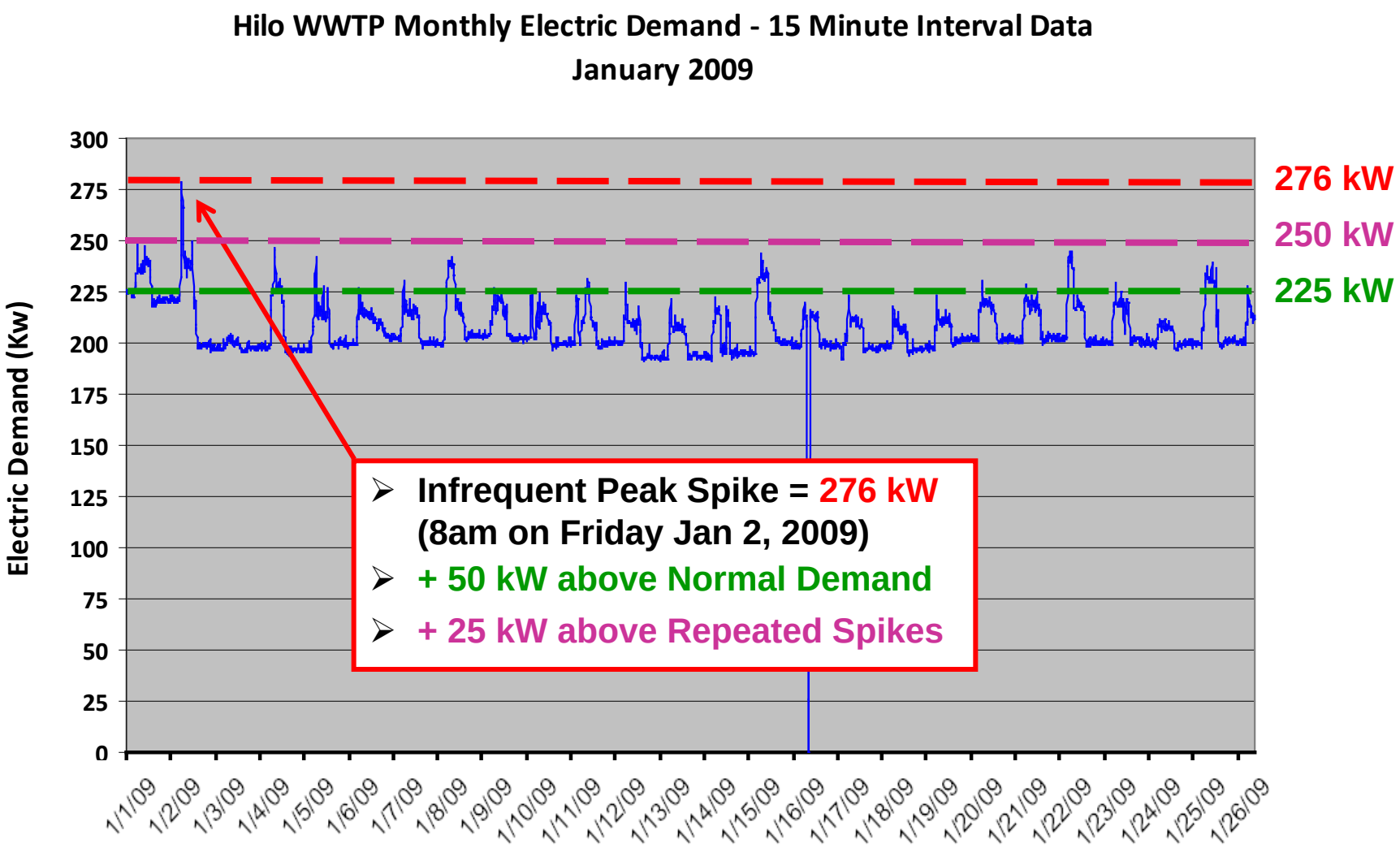
- 15% of site electric costs = >$82k/year*

Bill Period	Measured Peak Demand (kW)	Billed Peak Demand (kW)
Jul-08	276	282
Aug-08	270	279
Sep-08	264	276
Oct-08	258	273
Nov-08	270	279
Dec-08	264	276
Jan-09	276	282
Feb-09	252	270
Mar-09	258	267
Apr-09	256	267
May-09	264	270
Jun-09	252	264
AVERAGE	**263**	**274**



* Based on 2009 data collected from January 2009 – June 2009

Hilo WWTP – Electrical Demand Trend



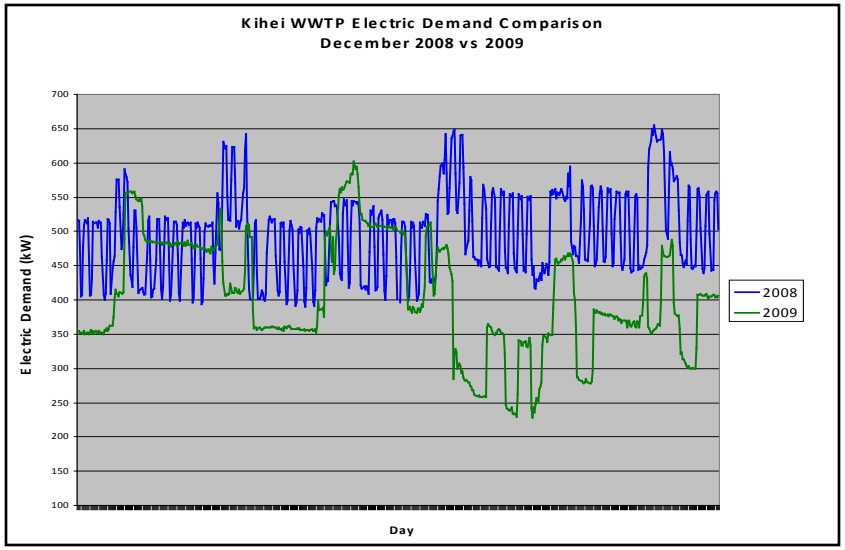
ECO #1 – Hilo WWTP Recommendation

Electrical Demand Management

- Meter site demand
- Monitoring load data
- Determine spike loads
- Eliminate infrequent spike loads:
  26 kW = $6,700/year
- Reduce regular spike loads:
  50 kW = $12,800/year

ECO #2 – Kihei Aeration Blower & UV Retrofit

- What a difference a year makes!
- Install new Turblex blower & UV system
- Estimated demand savings ~100 kW
- Estimated electrical savings ~1,000 MWh/yr



ECO #3 – Kailua UV Disinfection

- Currently off-line pending re-design
- Energy estimates at 15 MGD flow:
  - Old UV ~250 kW
  - New UV additional ~75 kW
- Payback < 2-3 years
- More efficient = less lamps to do the same job!

Preliminary ECO Results – Hilo WWTP

ECO No.	Recommendation	Potential Energy Reduction (kWh/yr)	Potential Demand Reduction (kW)	Potential Water Reduction (Gal/yr)	Potential Cost Savings ($/yr)	Estimated Implem. Cost ($)	Simple Payback (Years)
No-Cost Measures							
1	Operate Dewatering Odor Control Fan Only During Dewatering Periods	69,850	0	0	$19,100	$0	0.0
Low-Cost Measures							
2	Eliminate 1 Of 3 Primary Tanks In Use And Optimize Primary Sludge Pump Operations	39,900	14	0	$11,200	$5,000	0.4
Investment Grade Measures							
3	Electrical Demand Management	0	26	0	$6,600	$50,000	7.6
4	No. 2 Water Pumping System Improvements	35,000	0	6,500,000	$35,700	$100,000	2.8
5	Replace Lower Efficiency Motors With Higher Efficiency Motors	136,400	27	0	$44,300	$175,000	4.0
6	No. 3 Water Pumping System Improvements	94,800	10	0	$28,600	$220,000	7.7
Total Potential Electrical Energy Savings		**375,950 kWh/yr**					
Total Potential Electrical Demand Savings			**77 kW**				
Total Potential Water Savings				**6,500,000 Gal/yr**			
Total Potential Cost Savings					**$145,400 $/yr**		
Total Estimated Implementation Cost						**$550,000**	
Total Simple Payback							**3.8**

Preliminary ECO Results – Kailua WWTP

ECO No.	Recommendation	Potential Energy Reduction (kWh/yr)	Potential Demand[1] Reduction (kW)	Potential Water Reduction (Gal/yr)	Potential Cost Savings ($/yr)	Estimated Implem. Cost ($)	Simple Payback (Years)
Investment Grade Measures							
1	Electrical Demand Management	0	100-350 (738)[2]	0	$115,800	$75,000	0.6
2	Lighting System Improvements	122,100	25	0	$24,700	$154,000	6.2
3	Disinfection System Upgrades	438,000	50	0	$88,500	$500,000	5.6
4	Cogeneration	4,000,000	500	0	$658,000	$3,750,000	5.7
Total Potential Electrical Energy Savings		**4,560,100 kWh/yr**					
Total Potential Electrical Demand Savings			**675-925 kW**				
Total Potential Water Savings				**0 Gal/yr**			
Total Potential Cost Savings					**$887,000 $/yr**		
Total Estimated Implementation Cost						**$4,479,000**	
Total Simple Payback							**5.0**

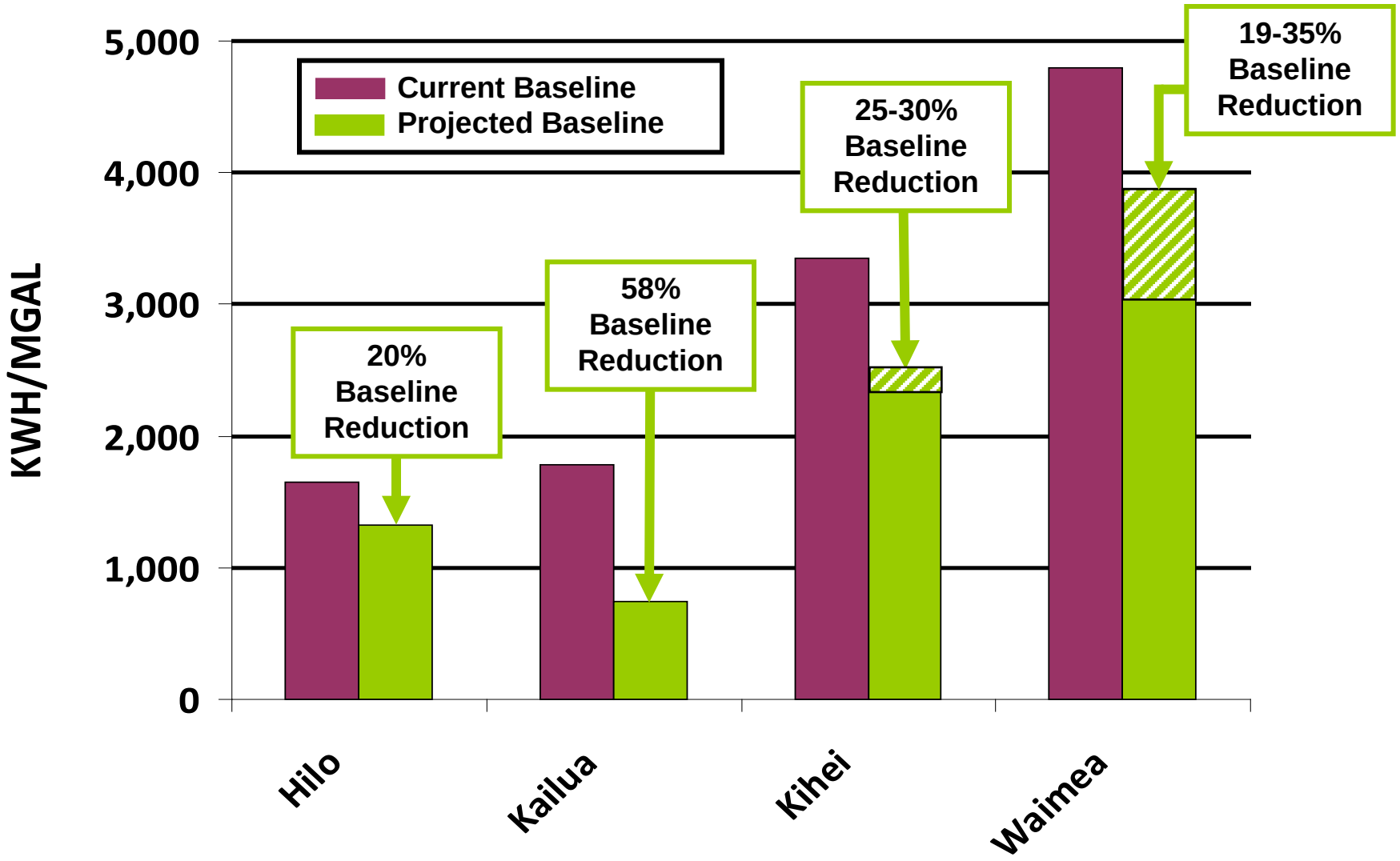
Preliminary ECO Results – Kihei WWTP

ECO No.	Recommendation	Potential Energy Reduction (kWh/yr)	Potential Demand[1] Reduction (kW)	Potential Water Reduction (Gal/yr)	Potential Cost Savings ($/yr)	Estimated Implem. Cost ($)	Simple Payback (Years)
Investment Grade Measures							
1	Effluent Water Management	26,000	10	0	$7,000	$25,000	3.6
2	Lighting System Improvements	22,700	4	0	$5,000	$43,000	8.6
3	Compressed Air System Improvements	105,700	6	0	$20,500	$130,000	6.3
Total Potential Electrical Energy Savings		**154,400 kWh/yr**					
Total Potential Electrical Demand Savings			**20 kW**				
Total Potential Water Savings				**0 Gal/yr**			
Total Potential Cost Savings					**$32,500 $/yr**		
Total Estimated Implementation Cost						**$198,000**	
Total Simple Payback							**6.1**

Preliminary ECO Results – Waimea WWTP

ECO No.	Recommendation	Potential Energy Reduction (kWh/yr)	Potential Demand Reduction (kW)	Potential Water Reduction (Gal/yr)	Potential Cost Savings ($/yr)	Estimated Implem. Cost ($)	Simple Payback (Years)
Investment Grade Measures							
1	Lighting System Improvements	9,140	3	0	$2,650	$7,000	2.6
2	Effluent Pumping System Improvements	8,000	10	0	$2,320	$17,500	7.5
3	Replace Lower Efficiency Motors With Higher Efficiency Motors	9,600	5	0	$2,800	$23,000	8.2
4	Install New Direct Drive, Higher Efficiency Blowers With Automated Process Controls	34,000-84,000	>6	0	$9,900-$24,400	$99,000-$244,000	10.0
Total Potential Electrical Energy Savings		**60,740-110,740 kWh/yr**					
Total Potential Water Savings				**0 Gal/yr**			
Total Potential Cost Savings					**$17,670-$32,170 $/yr**		
Total Estimated Implementation Cost						**$146,000-$291,500**	
Total Simple Payback							**8.3-9.1**

Projected Baselines w/ ECO Implementation



Emerging Stories! Digester Gas Use!

- Kailua and Hilo equipped with anaerobic digesters
- Both use digester gas for digester heating
- Excess gas is burned (Flare stack)
- Cogeneration study for Kailua (2004) indicated 600 KW cogen system possible with 13 MGD flow
- Cogeneration study is being updated, expected in 2010

Emerging Stories! Digester Gas Use!

- General rule of “thumb” 1 MGD ~30 KW cogen
- Options to make more digester gas:
  - Enhance digestion
  - Fat, oil & grease (FOG) addition
  - Other bio-waste

Emerging Stories! FOG

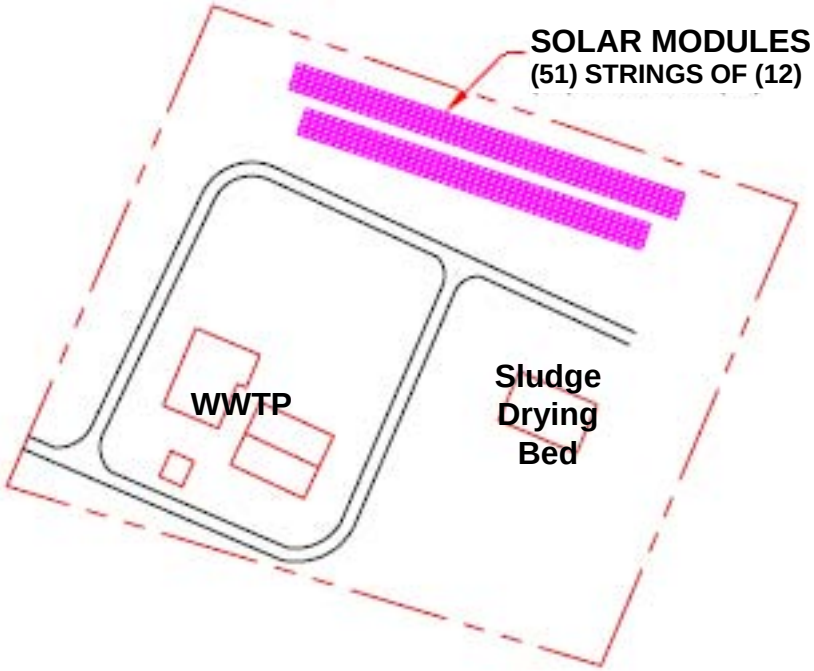
- High heating value (BTU)
- Excellent fuel source
- Disposal down the drain results in collection system blockages & headaches
- FOG recovery and reuse programs being developed throughout the world
- Keeps FOG out of landfills
- Could result in revenue source for agency

EPA

RENEWABLES! Location.. Location

- Solar
  - Waimea WWTP
- Wind
- Geothermal (deep well)
- Bio-mass (digesters)
- Hydropower (micro-turbines)

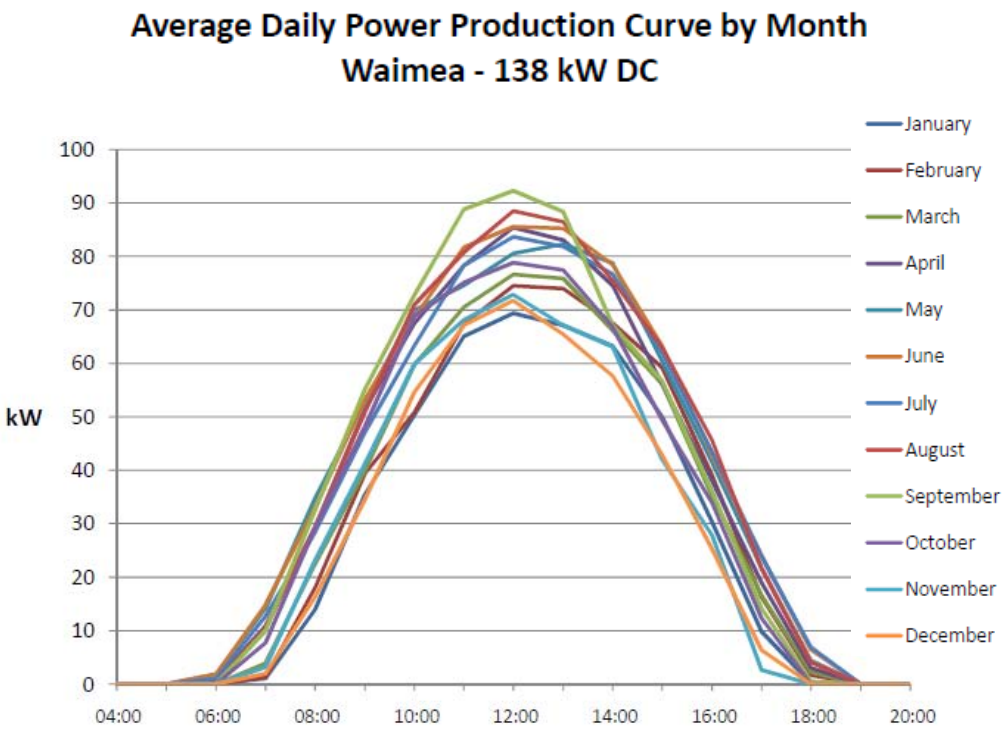
Waimea Solar PV System



- Proposed design:
  - 137.7kW DC
  - 112.9kW AC
  - Polycrystalline type
  - 612 REC AE-US 225W DC modules at fixed tilt (www.recgroup.com/usa)
  - Size of approximately 11,000ft^2

Waimea Solar PV System Cont…

- PV system cost
  - $799,194
- Est. energy impact
  - 203,077kWh/year
  - 65% of current electric use
  - $58,892/year*
- 13.5year* SPB



* $0.29/kWh and does not include rate schedule impacts or escalation over time

Energy Audit – Do's and Don'ts

- Three key's to effective auditing:

  "Information, *information*, & <u>information!</u>"
- Enlist team concept with plant personnel actively engaged in auditing
- Look beyond the numbers
- Understand local requirements and prohibitions

Energy Audit – Do's and Don'ts Continued…

- Confirm assumptions
- Evaluate "aggressively" but "keep it real"
- Make the auditing process a learning experience for *all participants*

Conclusions!

Good information + Right audit team

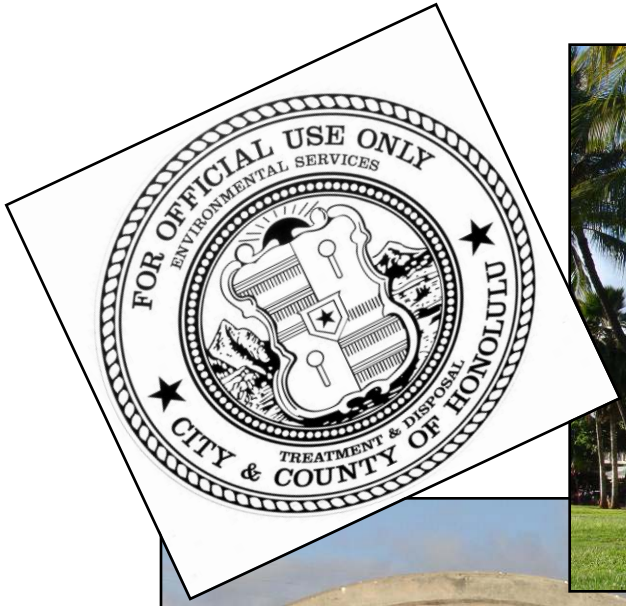
=

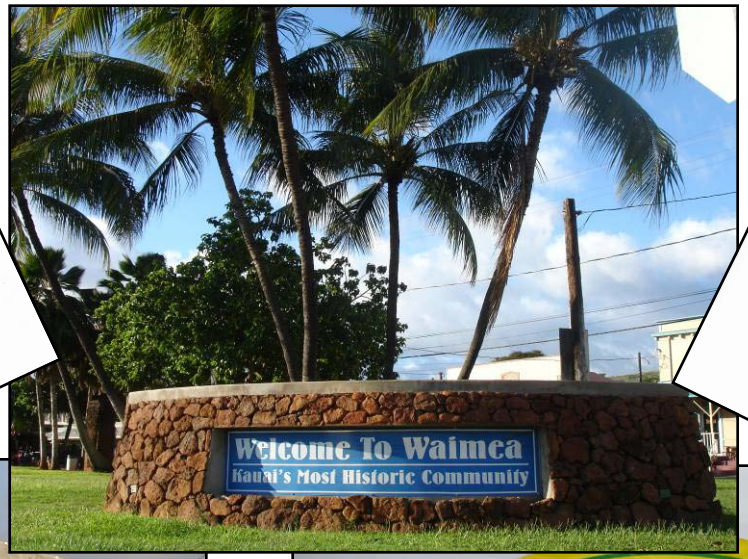
Enhanced energy utilization +

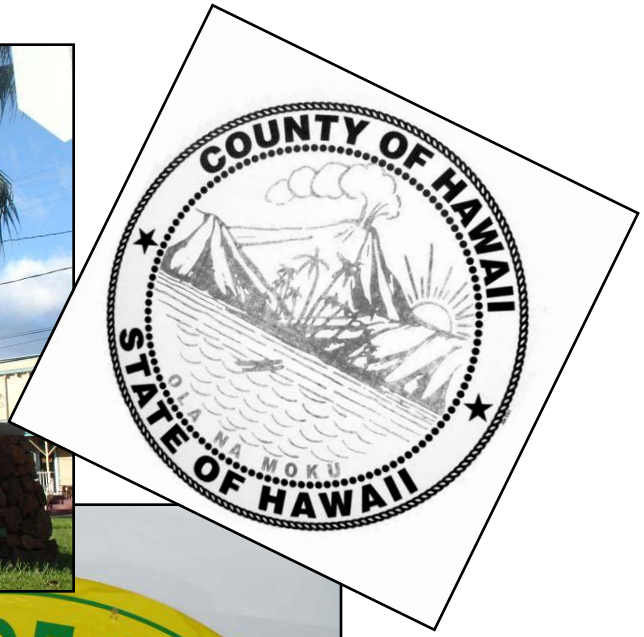
Increased operational understanding + $$$

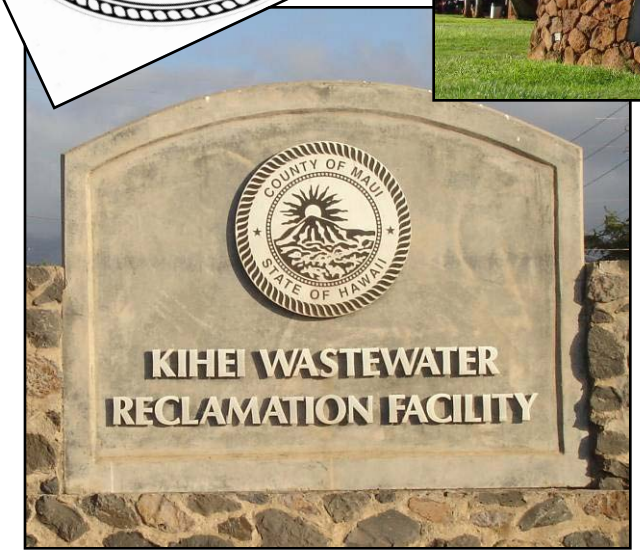
- Learn from the experience
- Better resource utilization awareness
- Energy / resource management improvements

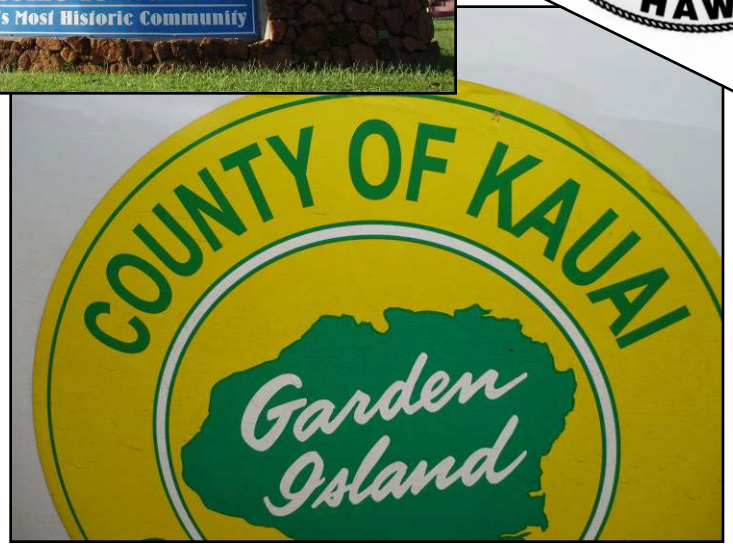
MAHALO!


FOR OFFICIAL USE ONLY
ENVIRONMENTAL SERVICES
TREATMENT & DISPOSAL
CITY & COUNTY OF HONOLULU


Welcome To Waimea
Kauai's Most Historic Community


COUNTY OF HAWAII
STATE OF HAWAII
OLA NA MOKU


COUNTY OF MAUI
STATE OF HAWAII
KIHEI WASTEWATER
RECLAMATION FACILITY


COUNTY OF KAUAI
Garden Island

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