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TECHNICAL MEMORANDUM

TO: Amanda Punton, Oregon Department of Land Conservation and Development and Denise Kalakay, Lane Council of Governments
FROM: Maureen Raad, RLA
DATE: May, 2011
SUBJECT: Evaluation of the utility of Light Detection and Ranging (LiDAR) technology in Local Wetland Inventories for select cities in the Multi-City/County Water Resources Assessment Project (MCWRAP).

INTRODUCTION

Purpose

This memorandum describes the methods, findings and conclusions from an evaluation of the use of Light Detection and Ranging (LiDAR) data in conducting Local Wetland Inventories (LWIs). The evaluation is intended to address the following questions.

1. Does the use of LiDAR data result in a wetland inventory with more quantifiably precise estimates of wetland boundaries?
2. Does the use of LiDAR data improve the efficiency of conducting a local wetland inventory?
3. Does the use of LiDAR data improve the efficiency of conducting a wetland assessment?

Lane Council of Governments (LCOG) secured a grant from Department of Land Conservation and Development (DLCD) to conduct this evaluation. The LiDAR evaluation component was included for the northern group of cities in the project managed by LCOG. This group includes five cities: Adair Village, Monroe, Harrisburg, Scio and Mill City.

LiDAR provides precise, accurate, and high-resolution images of the surface of the earth. The intent is to use these findings to improve the accuracy and efficiency of LWI preparation.

This memorandum is companion to a memorandum completed by Lane Council of Governments evaluating LiDAR's utility in conducting waterway inventories within the same group of cities.

SUMMARY OF CONCLUSIONS

The most robust use of LiDAR data to improve the LWI process is to use the data, in combination with ODFW stream data, to create more complete and horizontally accurate data layers describing natural and manmade ponds, lakes, rivers, streams and ditches. This would improve the efficiency of all steps in the LWI process.

- Base mapping would result in more accurate maps and access requests
- Wetland, waterbody and waterway mapping activities could focus on confirming features mapped using LiDAR and locating more difficult features

- Wetland assessment and significance determination would be based on a more accurate understanding of connectivity

BACKGROUND

Oregon LWI Procedures

As defined by the US Army Corps of Engineers (Environmental Laboratory 1987),

> *Wetlands are those areas that are inundated or saturated by surface water or groundwater at a frequency or duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.*

The Corps uses three characteristics of wetlands when making wetland determinations: vegetation, soil, and hydrology.

LWIs are planning-level wetland maps that are used to help plan development to avoid wetland impacts in Oregon. They are also used by local agencies to identify what permits might be needed for land development. LWI creation involves the review and interpretation of soil maps, existing wetland inventories, and aerial photos, as well as ground truthing, to locate areas where hydric soils, hydrology and hydrophytic vegetation indicate wetland resources. DSL has developed detailed inventory guidelines and rules for LWI. LWIs are intended to map all wetlands 0.5 acres or larger in size at an accuracy of approximately +/- 16.4 feet on a parcel-based map (Oregon Administrative Rules).

Oregon LWI procedures include the following basic steps.

- Collect existing data (DSL wetland, air photo, soil map, NWI, other Geographic Information Systems (GIS) data (if available).
- Develop a base map of potential wetlands
- Conduct field verification to refine wetland mapping
- Develop maps, functional assessments and report

Wetland determinations use three characteristics: hydrophytic vegetation, hydric soils and hydrology to define wetlands. LiDAR products do not provide direct information about any of these characteristics. It can tell us if vegetation is tall or short, but not if it requires saturation to survive. It does not inform our understanding of soil. It does not tell us if a location is saturated during the growing season. Despite this, LiDAR products do have the potential to help wetland scientists describe conditions on the ground more accurately.

LiDAR Data

LiDAR products provide a high-resolution depiction of the surface of the earth. They can be used to locate streams, ponds and other landscape features that have a strong relationship to topography. LCOG provided the LiDAR products used in this project. Flights were conducted in spring-summer 2009 to collect the LiDAR data. The LiDAR products include the following:

- Bare earth grid (3-ft resolution) – a digital elevation model
- Highest hit grid (3-ft resolution) – shows the tops of trees and buildings

- Intensity images (1.5-ft resolution) – a form of infrared photography
- Point cloud – 3-D shape and location of land, vegetation and buildings
- 2-ft topographic contours (created by LCOG using the bare earth grid)

LiDAR Evaluation Approach

This LiDAR evaluation focuses on using LiDAR data to inform several components of the LWI process. Each of these components is discussed separately in this memorandum. They include:

- Base mapping
- Wetland and waterbody mapping
- Wetland functional assessment

The Base Mapping and Wetland Assessment sections discuss the use of LiDAR qualitatively and do not compare LiDAR and non-LiDAR products. VAI completed these sections. Conclusions about the use of LiDAR data in these components are discussed in each section.

The Wetland and Waterbody mapping component is broken into two sections. The methodologies were kept simple. They focus on using LiDAR as a tool to improve map accuracy and streamline map production. The methodologies provide both quantitative and qualitative evaluations of the use of LiDAR in LWI preparation. VAI evaluated of the use of LiDAR in wetland and waterbody mapping and LCOG evaluated of the use of LiDAR in waterway mapping. LCOG's evaluation of LiDAR's utility in waterway mapping is included in a companion memo. Each of these sections includes a discussion of methods, findings and conclusions related to wetlands and waterbodies.

Conclusions in all sections focus on identifying the easiest and best use of LiDAR data in the LWI process.

BASE MAPPING

The purpose of the base mapping task in the LWI process is to assemble all available data and use them to identify likely wetland locations. GIS data are now broadly available in urbanizing areas. For this project LCOG used GIS mapping software to develop the base maps. **Table 1** summarizes the data used and their horizontal accuracy. The accuracy of the resulting base map is limited by the accuracy of these map layers.

Table 1. Base Map Data

Source: Data layer	Accuracy	Comment
USGS: 1:24,000 Topographic Quadrangle (Topo Quad)	+/- 40 feet	90% within 40 ft
USGS: National Wetland Inventory	+/- 40 feet	Topo Quad base
FEMA: Q3 Floodplain	+/- 40 feet	Topo Quad base
NRCS: SSURGO soil data	+/- 25 feet	per LCOG
USGS & EPA: National Hydrography Dataset	+/- 40 feet	4^{th} field HUCs
USGS & EPA: National Hydrography Dataset	+/- 40 feet	Water features
DSL: Delineated Wetlands (paper maps)	~ +/- 5 feet	Digitized by LCOG
National Agricultural Inventory: 2009 Color aerial photos	3.3 feet	Summer
LCOG: Streets and Boundaries (parcels, city limits, urban growth, study area, and county)	Varies	

Base maps are used to communicate preliminary findings to DSL and the public and to generate private land access permission requests by identifying the parcels that may include wetlands, waterbodies or waterways.

Access to private properties is needed to verify the presence of wetlands, waterbodies and waterways identified on the base maps. The access step in the LWI process is not insignificant. It often requires printing and mailing requests and processing responses some of which require a personal follow up call or direct communication with the field team to schedule site access. The standard urban parcel size is about 50 x 100 feet so a horizontal map accuracy of +/- 40 feet can result in access being requested for a neighboring parcel. This most often occurs with smaller streams and ponds that can be obscured on aerial photos by vegetation.

Base Mapping Conclusions

High resolution LiDAR topography can be used to create a more complete and horizontally accurate depiction of several of the datasets used in the base mapping process. Ponds, lakes and stormwater ponds can be accurately mapped using LiDAR data and air photos. Rivers, streams and ditches can also be more accurately mapped with LiDAR data but it is important to cross reference the results with a reliable source to ensure that linear topographic depressions that don't carry water aren't included in the layer. This is discussed in greater detail in the companion waterway evaluation memo.

Improving these datasets prior to conducting an LWI would increase the accuracy of property access requests and site visits resulting from potential wetland and waterbody locations.

WETLAND AND WATERBODY MAPPING

Selecting Cities for LiDAR Evaluation

Wetland consultants, SWCA, reviewed the base maps data described above to identify potential wetlands in the study areas. After review by DSL and the public, base maps were printed by SWCA at a scale of 1 inch = 200 feet on 22 x 34 inch sheets for use in the field. Scans of these maps are included in **Appendix A**. SWCA then performed the field investigation for each city that included both on- and off-site wetland evaluations. The methods used by SWCA to map wetlands, waterbodies and waterways in the field are described in the DRAFT Local Wetland Inventory Reports, for the City of Monroe (SWCA 2011) and the City of Adair Village (SWCA 2010).

SWCA's preliminary wetland findings were shared with LCOG and VAI. This information was used to select the cities to be used in the LiDAR evaluations. Adair Village and Monroe were selected to evaluate the use of LiDAR in mapping wetlands and waterbodies because they had the greatest number of wetlands of different types.

Non-LiDAR mapping methods and findings are described in the Non-LiDAR Mapping sections that follow. The non-LiDAR mapping method was the same for wetlands and waterbodies. This is followed by the discussion of the LiDAR methods, comparisons and findings.

Non-LiDAR Mapping Method

Non-LiDAR mapping for wetlands, waterbodies and waterways was completed by SWCA and LCOG in ArcGIS 9.3. The wetland boundaries, stream banks, ditch centerlines, and photo points were heads-up digitized in the office by wetland field personnel. In addition to the digital base map materials provided by LCOG, SWCA staff also referenced the aerial photos in **Table 2**.

Table 2. Additional Air Photo Resources

Source	Date	Use
LCOG	March 31, 2000, April 1, 2000	Soil saturation and drainage patterns
Corps of Engineers	May 1972, April 1961, May 1944	Soil saturation and drainage patterns
Google Earth	August 14, 2005, July 23, 2000, May 22, 1994	Waterways

Non-LiDAR Wetland and Waterbody Findings

The non-LiDAR wetland and waterbody findings from the LWI summary sheets and maps are summarized by City in **Table 3** and **Table 4** below. These tables include the unique wetland identifier (ID) and size. In addition, wetlands were categorized by hydrogeomorphic (HGM) classifications.

HGM-based classifications group wetlands based on their water, topography and geologic setting. Oregon uses the following HGM classes: riverine, depressional, slope, flats, lacustrine fringe, and estuarine fringe. Because HGM classes reflect topography as well as other indicators they were tracked to evaluate the usefulness of LiDAR data in mapping wetlands in a specific HGM class. For example, depressional wetlands are found in topographic depressions which are readily observable in LiDAR data while slope wetlands occur in a wide range of conditions with no clear topographic boundaries.

In Adair Village 15 wetlands and one non-jurisdictional sewage lagoon were identified. These features included 16 polygons. Of these, six were previously delineated or came from other sources and one was added later in the project. These features were not used in the LiDAR evaluation and are shaded in Table 3.

Table 3. Non-LiDAR Wetland and Waterbody Findings for Adair Village

ID	HGM Class	Size (Acres)	DSL File Number
AV-1	Riverine	0.45	
AV-2	Slope	1.18	WD1999-0255
AV-3	Slope, Flat	1.80	WD1997-0371
AV-4	Slope	0.87	
AV-5	Depressional	0.14	
AV-6	Slope	1.92	WD1997-0371
AV-7	Depressional	0.65	
AV-8*	Riverine	11.11	
AV-9	Depressional	0.86	
AV-10	Depressional	2.12	
AV-11	Depressional	1.85	
AV-12	Slope, Flat	0.86	
AV-13	Slope	5.29	WD2006-0673
AV-14	Slope	0.74	WD2006-0673
AV-15*	Slope	1.58	WD2006-0673
Sewage Lagoon (AV-SL)	Depressional	0.37	

* Multiple Polygons

The features that were used include three riverine polygons, four depressional polygons and four slope polygons. Flat wetlands were always associated with slope wetlands and so were not tracked separately for the evaluation.

In Monroe 12 wetlands were identified. These resource features included 18 polygons. Of these features one was previously delineated and was not used in the LiDAR evaluation. It is shaded in Table 4. The features that were used include 8 slope polygons and 9 depressional polygons.

Table 4. Non-LiDAR Wetland and Waterbody Findings for Monroe

ID	HGM Class	Size (Acres)	DSL File Number
M0-1	Depressional	4.82	
M0-2	Depressional	1.16	
M0-3	Depressional	1.87	WD1998-0401
M0-4	Depressional	0.36	WD2009-0286
M0-5*	Slope	18.15	WD2009-0286
M0-6	Slope	1.57	
M0-7	Slope	0.22	
M0-8	Slope	0.44	
M0-9*	Depressional	4.56	WD2003-0704
M0-10	Depressional	0.75	
M0-11	Depressional	4.73	
M0-12	Slope	0.38	

* Multiple Polygons

LiDAR Wetland and Waterbody Mapping Method

LiDAR wetland and waterbody mapping was also completed in ArcGIS 9.3. The wetland and waterbody boundaries were heads-up digitized in the office by wetland personnel. VAI staff relied on SWCA field notes, available map, photo and digital data to locate boundaries. This data included:

- Hand drawn field maps produced by SWCA on hard copy base maps
- Air photo resources in **Table 2**
- Base map data in GIS
- 2-ft LiDAR contours
- Bare earth grid (displayed as a hillshade with a vertical exaggeration of 5x)

The mapping process was iterative and included the following basic steps.

- SWCA field maps were examined in conjunction with aerial photos to understand intended boundary locations. Attention was paid to air photo signatures indicating saturation and hydrophytic vegetation and the location of hand drawn boundaries, hydric soils, waterways, and tax lots.
- Wetland polygons were digitized based on their correspondence to the above data and the LiDAR topographic information (2-ft contours and bare earth grid).
- Wetland polygons were QA/QC'd by senior wetland staff and edited as appropriate.

LiDAR – Non-LiDAR Wetland and Waterbody Mapping Comparison

The completed LiDAR mapping results were compared to the non-LiDAR mapping results using ArcGIS 9.3. The evaluation was focused on describing how the polygons were similar or different in both size and horizontal position. The methods and findings of the ***percent offset*** and ***coincident ratio*** comparisons are described below. The intent was to provide quantitative information that could be used to support a qualitative assessment of how LiDAR informed or did not inform the mapping process.

A total of 28 polygons were evaluated in both cities, providing a relatively small sample size. The split between Depressional and Slope polygons is about even but Riverine polygons are not well represented. The count and percentage of these polygons in each HGM class are listed in **Table 6**.

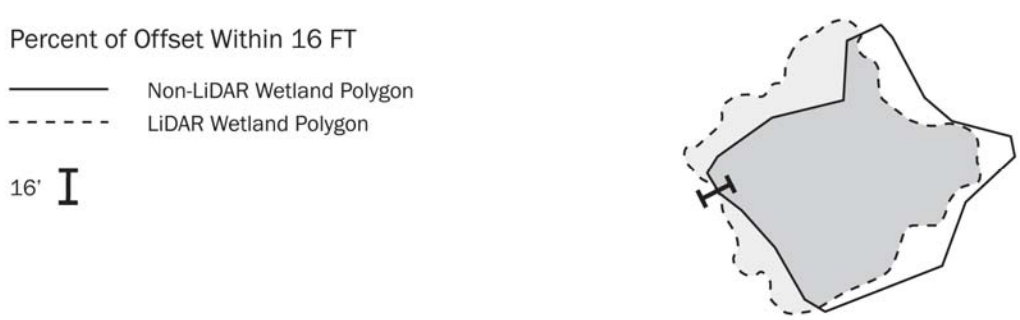
Table 6. HGM Class of Evaluated Polygons

	Adair Village		Monroe		Combined	
HGM Class	**Count**	**Percent**	**Count**	**Percent**	**Count**	**Percent**
Depressional	4	36%	9	53%	13	46%
Slope	4	36%	8	47%	12	43%
Riverine	3	28%	0	0%	3	11%

Comparison Methods

Approximate ***percent offset*** was used to generally describe the horizontal coincidence between the LiDAR and Non-LiDAR boundary locations. The 16 foot distance was selected because it approximates the horizontal accuracy required by DSL for LWI maps (5 meters or 16.4 feet). The concept is illustrated in **Figure 1**. The comparison focused on the 16-foot offset but a 25-foot offset was reviewed concurrently to provide additional information.

Figure 1. Percent Offset Diagram

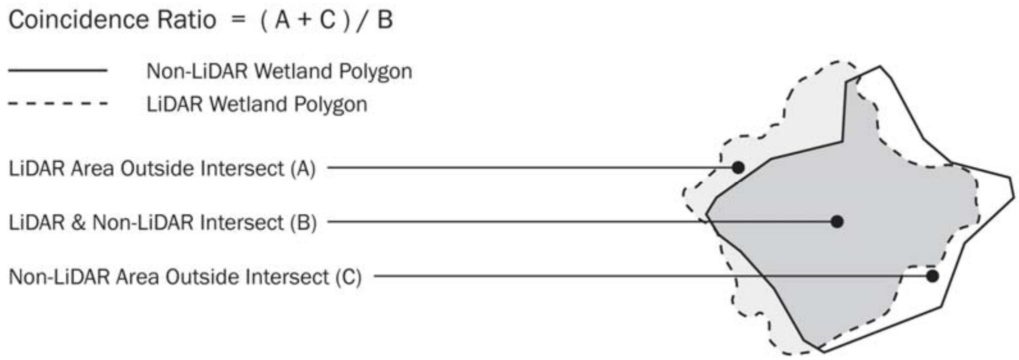


To determine the approximate ***percent offset*** within 16 feet, the distance between the LiDAR and non-LiDAR polygon boundaries was visually compared at a standard scale of 1:400 (approximately 1 inch = 33 feet). A scale was used to measure the distance between the polygon boundaries around the entire perimeter. The percent of boundary length where polygon boundaries were within the designated distance was estimated by the technician.

This process could also be automated using GIS tools and scripts but given the small number of polygons to be evaluated (28) there was no time savings to be gained automating the task. In addition, the precision afforded by a GIS-based approach was not required to generally describe horizontal offset.

A ***coincidence ratio*** was used to quantify both the aerial and spatial coincidence between the LiDAR and non-LiDAR polygons. The concept is illustrated in **Figure 2.**

Figure 2. Coincidence Ratio Diagram



To determine the ***coincidence ratio***, the LiDAR and non-LiDAR polygons were intersected using ArcGIS 9.3. There are a number of tool options in GIS that can be used to complete this comparison. For this assessment the *Intersect* tool in the *Overlay* toolbox was used. The areas of the resulting intersected polygons were defined using the *Calculate Areas* function. These values were then copied into an existing Excel spread sheet containing the Non-LiDAR polygon data. The *Union* tool could also have been used which would have allowed the calculations to be done within GIS. For this comparison calculations were done in Excel because it was a convenient application for tracking both qualitative and quantitative information and for making comparisons between the ***percent offset*** and ***coincidence ratio*** evaluations.

In Excel the intersected area was subtracted from both the LiDAR and non-LiDAR polygon areas to define the areas from each GIS dataset that were outside the intersected polygon. These areas were summed and then divided by the area of the intersected polygon. The resulting ratio describes the aerial and spatial disagreement between the LiDAR and non-LiDAR results.

Comparison Findings

The quantitative findings are described by city in **Table 7** and **Table 8**. LiDAR and non-LiDAR polygons are illustrated in **Figure 3** and **Figure 4** in **Appendix B**. The results of the two assessments were grouped into good, fair and poor scoring categories.

The ***percent offset*** scores were ranked as follows:
100–90 = good, 89–75 = fair, <75 = poor.

The ***coincidence ratio*** scores were ranked as follows:
0.00–0.20 = good, 0.21–0.40 = fair, >0.41 = poor.

Table 7. LiDAR – Non-LiDAR Wetland and Waterbody Mapping for Adair Village

ID	HGM Class	Coincidence Ratio		Percent Offset			
		outside area /intersect area	Rank	% boundary length 16 ft	Rank	% boundary length 25 ft	Rank
AV-1	Riverine	0.61	Poor	100	**Good**	100	**Good**
AV-3	Slope, Flat	0.14	**Good**	70	Poor	95	**Good**
AV-4	Slope	0.41	Poor	75	Fair	85	Fair
AV-5	Depressional	0.34	Fair	100	**Good**	100	**Good**
AV-6	Slope	0.16	**Good**	85	Fair	95	**Good**
AV-7	Depressional	0.46	Poor	40	Poor	85	Fair
AV-8a	Riverine	0.29	Fair	70	Poor	80	Fair
AV-8b	Riverine	0.62	Poor	30	Poor	55	Poor
AV-9	**Depressional**	0.19	**Good**	90	**Good**	100	**Good**
AV-12	Slope, Flat	0.39	Fair	50	Poor	75	Fair
AV-SL	**Depressional**	0.13	**Good**	100	**Good**	100	**Good**

Eleven wetland and waterbody polygons were evaluated in Adair Village.

In the ***percent offset*** comparison polygons ranked as follows:

16-foot offset:
36 percent = good (4 polygons)
19 percent = fair (2 polygons)
45 percent = poor (5 polygons)

25-foot offset:
55 percent = good (6 polygons)
36 percent = fair (4 polygons)
9 percent = poor (1 polygons)

In the ***coincidence ratio*** comparison polygons ranked as follows:
36 percent = good (4 polygons)
28 percent = fair (3 polygons)
36 percent = poor (4 polygons)

Good ranks are bolded in the above table. The HGM class is bolded for polygons that ranked *good* in both the **percent offset** (16-foot offset) and ***coincidence ratio*** comparisons. Two depressional polygons fell into this category. One riverine and one depressional feature ranked *poor* in both comparisons.

Table 8. LiDAR – Non-LiDAR Wetland and Waterbody Mapping for Monroe

ID	HGM Class	Coincidence Ratio		Percent Offset			
		outside area /intersect area	Rank	% boundary length 16 ft	Rank	% boundary length 25 ft	Rank
MO-1	Depressional	0.17	**Good**	60	Poor	85	Fair
MO-2	Depressional	0.29	Fair	50	Poor	75	Fair
MO-3	**Depressional**	0.19	**Good**	85	**Good**	95	**Good**
MO-5a	Slope	0.22	Fair	80	Fair	90	**Good**
MO-5b	Slope	0.83	Poor	100	**Good**	100	**Good**
MO-5c	Slope	0.70	Poor	45	Poor	95	**Good**
MO-5d	Slope	1.61	Poor	60	Poor	100	**Good**
MO-6	Slope	0.29	Fair	50	Poor	75	Fair
MO-7	Slope	1.00	Poor	50	Poor	70	Poor
MO-8	Slope	0.79	Poor	60	Poor	100	**Good**
MO-9a	**Depressional**	0.20	**Good**	100	**Good**	100	**Good**
MO-9b	Depressional	0.34	Fair	90	**Good**	100	**Good**
MO-9c	Depressional	0.47	Poor	80	Fair	95	**Good**
MO-9d	Depressional	0.22	Fair	75	Fair	90	**Good**
MO-10	Depressional	0.50	Poor	50	Poor	60	Poor
MO-11	Depressional	0.17	**Good**	80	Fair	90	**Good**
MO-12	Slope	1.31	Poor	30	Poor	70	Poor

Seventeen wetland and waterbody polygons were evaluated in Monroe.

In the ***percent offset*** comparison polygons ranked as follows:

16-foot offset:
24 percent = good (4 polygons)
24 percent = fair (4 polygons)
52 percent = poor (9 polygons)

25-foot offset:
64 percent = good (11 polygons)
18 percent = fair (3 polygons)
18 percent = poor (3 polygons)

In the ***coincidence ratio*** comparison polygons ranked as follows:
24 percent = good (4 polygons)
29 percent = fair (5 polygons)
47 percent = poor (8 polygons)

Good ranks are bolded in the above table. The HGM class is bolded for polygons that ranked *good* in both the **percent offset** (16-foot offset) and ***coincidence ratio*** comparisons. Two depressional polygons fell into this set. Five slope and one depressional feature ranked *poor* in both comparisons.

LiDAR – Non-LiDAR Mapping Comparison Assessment

Summary findings for both cities are included in **Table 9.**

Table 9. LiDAR – Non-LiDAR Wetland and Waterbody Mapping for Monroe and Adair Village

Coincidence Ratio			Percent Offset					
			% boundary length 16 ft			% boundary length 25 ft		
Rank	Number	Percent	Rank	Number	Percent	Rank	Number	Percent
Good	8	29%	Good	8	29%	Good	17	61%
Fair	8	29%	Fair	6	21%	Fair	7	25%
Poor	12	42%	Poor	14	50%	Poor	4	14%

In the ***percent offset*** (16-foot offset) comparison the LiDAR and Non-LiDAR polygons did not compare very favorably. Just 29 percent of the polygons had a *good* rank (4 depressional, 3 slope, and 1 riverine). Fifty percent of the polygons had a *poor* rank (4 depressional, 8 slope, and 2 riverine).

The fourteen *poor* ranked polygons had a couple of things in common. In several cases the position of the digital non-LiDAR boundary differed from the boundary recorded on the field maps. This type of change is not uncommon in LWI mapping. Wetland scientists may refine their field-based boundary locations as either new information or a greater understanding of the site is gained. For example, a marginal plant community can be observed in the field and only later, when a source of hydrology is discovered, is the area considered a wetland. This illustrates the importance of field work in the LWI mapping process. In these cases the LiDAR boundary was fairly close to the boundary on the field map but was different from the digital non-LiDAR boundary. In other *poor* ranked polygons, topography did not inform the location of the boundary. Many were grassy gradually sloped areas. Eight polygons ranked *good* in the ***percent offset*** (16-foot offset) comparison. All were well defined by topography. Two were ponds and three were linear drainage features with steep sides.

The results of the ***percent offset*** (25-foot offset) comparison were more favorable. Sixty-one percent of the polygons had a *good* rank (9 depressional, 7 slope, and 1 riverine).

The high percentage of *good* ranking polygons in the ***percent offset*** (25-foot offset) comparison is expected not only because the 25-foot threshold artificially minimizes the discrepancy between polygons, but also because both GIS layers were based on the same field maps. An attempt at matching the Non-LiDAR polygons without the guidance of field maps would result in lower percentages of good and fair ranking polygons. This high percentage also indicates that the boundaries of many of these wetlands were clearly defined by the LiDAR products (bare earth DEM and derived contours) and visible on aerial photos. Locations with significant topographic variation are expensive to improve and so tend to persist as the land around them is transitioned to other uses like agriculture or residential, commercial or industrial development. Only fourteen percent of the polygons had a *poor* rank (1 depressional, 2 slope, and 1 riverine).

The ***coincidence ratio*** comparison captured the subtle differences between the non-LiDAR and LiDAR boundary locations even when these variations were within the 16-foot horizontal offset. The percent *good*, *fair* and *poor* in the ***coincidence ratio*** comparison was comparable to the rankings in the ***percent offset*** (16-foot offset) comparison. This improved the confidence in the findings of both comparisons. Twenty-nine percent of the polygons in the ***coincidence ratio*** comparison had a *good* rank (6 depressional and 2 slope). Fifty percent of the polygons with a *good* rank in the ***coincidence ratio*** comparison also ranked *good* in the ***percent offset*** (16-foot offset) comparison. All but one ranked *good* in the ***percent offset*** (25-foot offset) comparison. Most of the boundary location deviations were caused by technicians responding to the detailed topographic information provided by the LiDAR data in locating the boundary line. However, in reviewing the LiDAR and non-LiDAR boundaries it was generally not clear which boundary location more accurately reflected conditions on the ground. The results from field work, where on-site access was granted, are assumed to be the more accurate data.

The 12 polygons (42 percent) that ranked *poor* in ***coincidence ratio*** comparison did so for a couple of reasons. Eight also ranked *poor* in the ***percent offset*** (16-foot offset) comparison. In these cases the LiDAR boundary was fairly close to the boundary on the field map but was different from the digital non-LiDAR boundary. In many of the *poor* ranked polygons the 2-foot contour interval required some interpolation by the technician to define the boundary – even when combined with the bare earth grid. Seven of these were slope wetlands where topography did little to inform the boundary location. *Poor* rank in the ***coincidence ratio*** comparison was also seen in sloped linear ditches that were topographically constrained as well as in some shallow depressions. Linear feature boundaries could be within the 16-foot offset but the length of the feature amplified the difference between the LiDAR and non-LiDAR polygons in the ***coincidence ratio*** comparison. As with the *good* ranking polygons it was generally not clear which boundary location more accurately reflected conditions on the ground for sites where access was not provided.

Wetland and Waterbody Mapping Conclusions

LWI mapping cannot be completed with out a field investigation, though the use of LiDAR data in LWI mapping can improve the accuracy and efficiency of some components.

Based on the findings from the ***percent offset*** and ***coincidence ratio*** comparisons it is difficult to conclude that the use of LiDAR data in wetland mapping would result in more quantifiably precise estimates of wetland boundaries, especially when lumping together all types of wetlands. LiDAR derived boundary locations would correspond more closely to topographic features on the ground; however, those features might not describe the wetland boundary. Depressional wetlands shows the most promise while slope wetlands, whose boundaries have little or no correspondence to topography, show the least. Eighty percent of slope wetlands ranked *poor* in at least one of the two primary comparisons.

LiDAR data does improve the mapping accuracy of some depressional wetlands and waterbodies. Features associated with depressions – especially ponds – ranked *good* in both comparisons. Ponds were reliably in the +/- 16-foot offset range because their boundaries were based on strong topographic breaks and water visible on air photos. Depressional polygons also did well overall. Sixty percent ranked *good* in at least one of the two primary comparisons. Despite improvements using LiDAR, accuracy would only reliably be in the +/- 25-foot offset range for depressional polygons other than ponds. Sixty-nine percent of all depressional polygons met the +/- 25-foot offset threshold. Since depressional wetlands often occur in combination with other wetland types like slope and riverine, LiDAR-derived depressional wetlands would still need to be field verified so boundaries could be adjusted to match observed conditions.

LiDAR data can improve the efficiency of conducting a local wetland inventory by allowing agencies and/or wetland consultants to develop preliminary maps that accurately show the locations of ponds and some depressional wetlands and waterbodies. These features could then be confirmed, rather than mapped, in the field and with air photos.

WETLAND ASSESSMENT

The Oregon Freshwater Wetland Assessment Method (OFWAM) provides qualitative information on the relative value of wetlands. The assessment methodology focuses on three basic wetland functions: habitat (wildlife and fish), water quality, and hydrologic control. This ranking system is summarized in **Table 10**.

Table 10. OFWAM Functions and Rating Categories

Wetland Functions	Ranking Categories
Wildlife Habitat	**High.** Wetland provides diverse wildlife habitat
	Medium. Wetland provides habitat for some wildlife species
	Low. Wetland does not provide wildlife habitat
Fish Habitat	**High.** Wetland's fish habitat function is intact
	Medium. Wetland's fish habitat function is impacted or degraded
	Low. Wetland's fish habitat function is lost or not present

Water Quality	**High.** Wetland's water-quality function is intact
	Medium. Wetland's water-quality function is impacted or degraded
	Low. Wetland's water quality function is lost or not present
Hydrologic Control	**High.** Wetland's hydrologic control function is intact
	Medium. Wetland's hydrologic control function is impacted or degraded
	Low. Wetland's hydrologic control function is lost or not present

Modified from (Pacific Habitat Services, Inc. 2010)

To perform an OFWAM assessment consultants refer to a broad range of data that describe both watershed and site conditions. Wetland characterization questions focus on land uses in the watershed, known water quality limitations, the wetlands geographic position in the landscape, vegetation structure, connectivity between wetlands and other waterbodies, and the source and reasons for wetland hydrology.

Wetland Assessment Conclusions

Assessment questions that address the proximity of a wetland, waterbody or waterway to a land use use *"within 500 feet"* as the threshold. Refinements to resource boundaries using LiDAR are unlikely to effect how these questions are answered.

Hydrologic connectivity is important to several questions and assessed functions. It provides an understanding of a wetlands landscape position and relationship to other resources in the landscape and helps describe wildlife and fish habitat functions. Connectivity to a water quality limited stream is also important in determining wetlands significance.

As mentioned in the base mapping conclusions discussion high resolution LiDAR topography can be used to create a more complete and horizontally accurate map of ponds, lakes, rivers, streams and ditches. Improving these datasets will make it easier to determine if wetlands, ponds and waterways are hydrologically connected.

REFERENCES

Environmental Laboratory. 1987. Corps of Engineers Wetlands Delineation Manual, Technical Report Y-87-1. U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Oregon Administrative Rules:
LWI: http://arcweb.sos.state.or.us/rules/OARS_100/OAR_141/141_086.html

Pacific Habitat Services, Inc. 2010. Local Wetland Inventory and Riparian Corridor Assessment for the Glenwood Area of Springfield, Oregon. Prepared for Lane Council of Governments and the City of Springfield. Prepared by J. van Staveren, M. Eccleston, and S. Eisner. PHS Project Number 4495.

SWCA, December 2010. DRAFT Local Wetland Inventory Report, City of Adair Village, Benton County, Oregon. Prepared for Lane Council of Governments and the City of Adair Village.

SWCA, January 2011. DRAFT Local Wetland Inventory Report, City of Monroe, Benton County, Oregon. Prepared for Lane Council of Governments and the City of Monroe.

APPENDIX A
Field Maps

APPENDIX B
Figures